Report to the U. S. National Park Service

on

THE PHYSICAL, BIOLOGICAL AND GEOLOGICAL CHARACTER OF THE AREA SOUTH OF C-111 CANAL IN EXTREME SOUTHEASTERN EVERGLADES NATIONAL PARK, FLORIDA

by

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Terence M. Thomas and Nancy Maynard

(Project Period--February 16 to March 16, 1967)
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The Physical, Biological and Geological Character of the Area South of C-111 Canal in Extreme Southeastern Everglades National Park, Florida

by

Durbin C. Tabb, Taylor R. Alexander [1]
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INTRODUCTION

An earth plug in Canal C-111 in South Dade County, Florida, (Figures 1 and 2), located where the canal passes under U. S. Highway No. 1, now prevents the free flow of water in the canal. If this plug is removed it will permit unobstructed intrusion inland of saline water during dry seasons and drainage into Barnes Sound (Southern Biscayne Bay) of much fresh-water that formerly flowed overland into Florida Bay in the area west of Highway 1. It is believed that this canal will permit un-restricted spill-over of saline water onto the sawgrass habitat of eastern Everglades National Park and cause irreversible damage to the unique flora and fauna there.

During the discussions over the necessity for a salinity barrier, the statement has been made that a salt control structure is not required where the plug now exists because the region to the south in Everglades National Park is already a saline marsh. This contention may have had its origin in a paper by Egler (1952) entitled "Southeast Saline Everglades Vegetation, Florida, and its Management". The title of the paper is misleading, as recognized by Dr. Egler himself, since

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[1] Taylor R. Alexander, Professor of Botany, University of Miami, Coral Gables, Florida.

Figure 1: Map of south Florida showing the study area with respect to Miami, Biscayne Bay and Cape Sable. Hydrographic sampling stations where records of salinity have been taken regularly during the period 1964 through 1966 are also indicated.

Figure 1

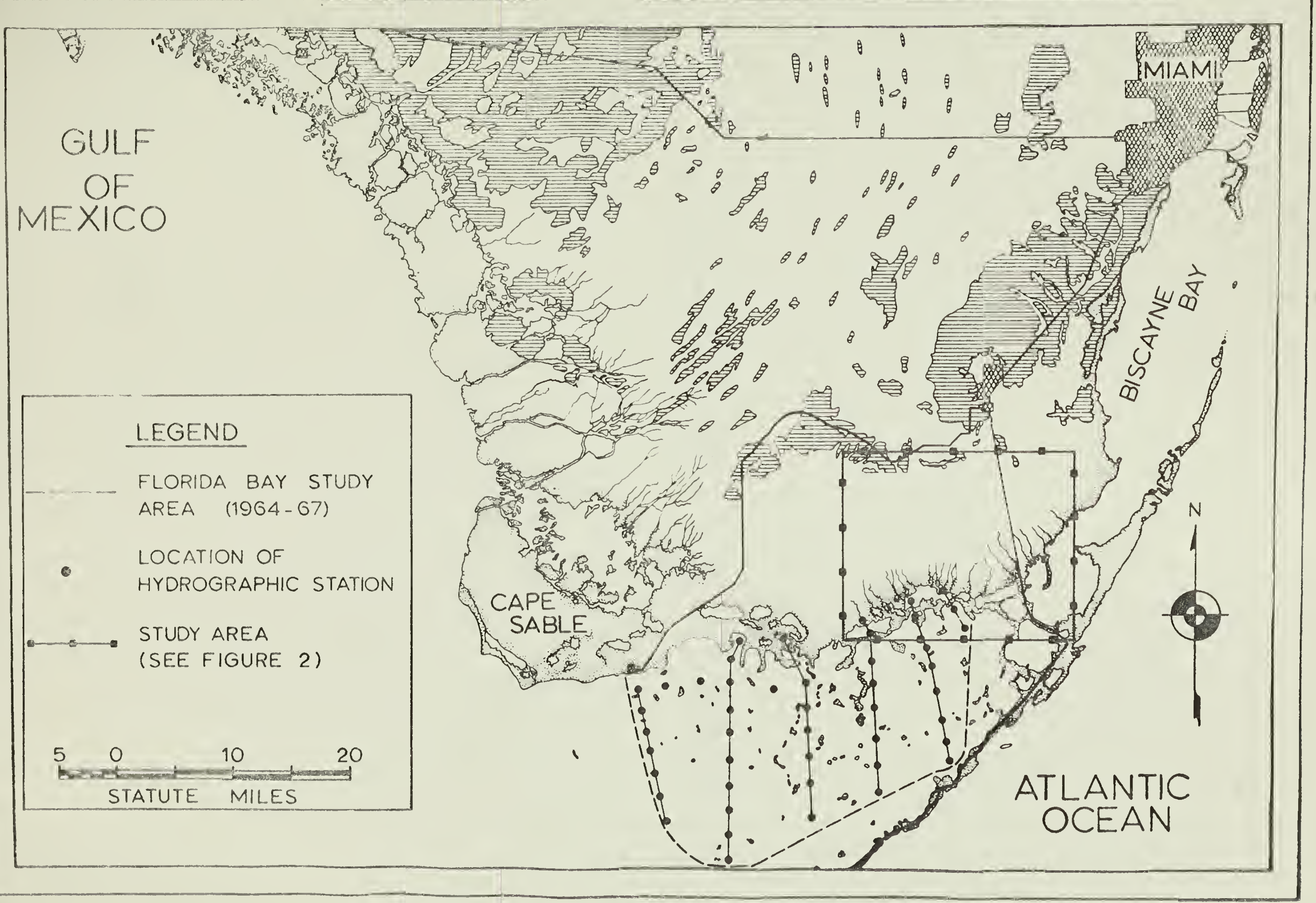
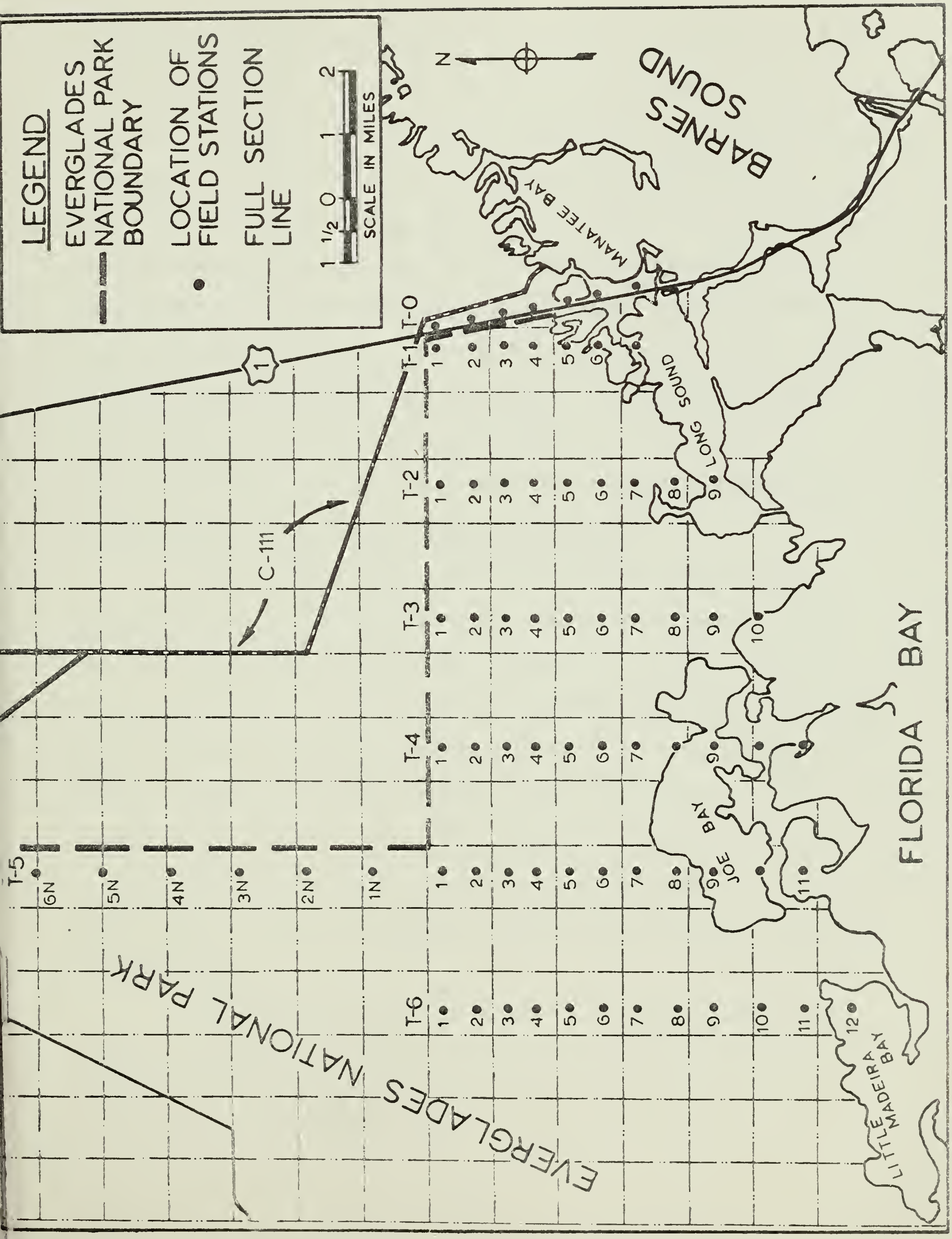

GULF OF MEXICO
MIAMI
BISCAYNE BAY
CAPE SABLE
ATLANTIC OCEAN
N
LEGEND
FLORIDA BAY STUDY AREA (1964-67)
LOCATION OF HYDROGRAPHIC STATION
STUDY AREA (SEE FIGURE 2)
5
0
10
20
STATUTE MILES

Figure 2: Location of sampling stations in relation to the boundary of Everglades National Park, U. S. Highway 1, and Canal C-111.

Figure 2


LEGEND
EVERGLADES NATIONAL PARK BOUNDARY
LOCATION OF FIELD STATIONS
FULL SECTION LINE
1 1/2 0 1 2
SCALE IN MILES
N
BARNES SOUND
MANATEE BAY
LONG SOUND
FLORIDA BAY
JOE BAY
LITTLE MADEIRA BAY
EVERGLADES NATIONAL PARK
C-111
1
T-0
T-1
T-2
T-3
T-4
T-5
T-6
1N
2N
3N
4N
5N
6N
1
2
3
4
5
6
7
8
9
10
11
12

he points out in the first paragraph of his Abstract and Summary (p.213) that "By referring to this area as saline it is not implied that the region is continuously saline or that the marl was formed under saline conditions. The term is used to indicate that the vegetation is in adjustment with sporadic hurricane floods of ocean waters, which not only serve as dissemination agents for certain kinds of plants, but which affect the presence and distribution of other plants according to their tolerance to salinity. In respect to this sporadic saline factor, the region can be segregated from the rest of the Florida Everglades. (As a nomenclatural term, 'Saline Everglades' is thus analogous to various 'hurricane forests' and 'fire types', names with reference to historic events and not the continuing environment". *

Out of the controversy over the probable effects of an uncontrolled canal on Everglades Park one undisputed fact arose: no one really knew what the region was like in quantitative terms. No valid conclusions could be reached about the harm that might result from spillover of saline water from an uncontrolled sea-level canal unless serious study were made of the conditions that exist in the Park at present, and of the past ecological history of the region. Is the area, essentially a saline marsh as some have contended, or is it a fresh-water habitat which would be damaged by invasion by saline water during dry seasons and drought periods?

Recognizing the need for resolution of these questions, the National Park Service contracted the Institute of Marine Science to under-

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*Underlined for emphasis by authors.

take a program of data gathering. This study, which spanned a thirty-day period, utilized a number of the resources and talents of the University of Miami, Institute of Marine Science and of the Department of Botany in collecting and analysing the data. The authors gratefully acknowledge the advice, opinions and considerable time spent on the project by many members of the Institute of Marine Science staff in the disciplines of geology, marine biology, ichthyology, radiology, oceanography, algology and fishery sciences. Dr. Conrad Neuman supervised the analysis of the sediment samples. Dr. Enrico Bonatti provided the services of the X-ray diffractometer. Dr. E. J. Ferguson Wood and Miss Nancy Maynard confirmed the identifications and analysis of the large series of diatoms from the periphyton community. Mr. Wesley Rouse identified the fishes and crustaceans from the collections. Dr. Taylor R. Alexander collected and identified the higher plants and plotted their distribution. Mr. Terence M. Thomas was in charge of field operations. Mr. Durbin C. Tabb supervised the planning and conduct of the program, and the analysis of results.

METHODS

During the field studies a network of 82 stations was established (Figure 2) Sixteen of these, two at the plug and seven pairs along Highway No. 1, were visited for salinity observations only. All the other stations produced salinity samples, sediment samples, collections of plants and animals, and measurements of the periphyton zone.

Following an initial survey trip of February 16, 1967 all stations were visited by helicopter. This permitted far greater coverage than usual in the short time available.

Station 1 on each of the six main transects was visited twice to confirm the station position, and to determine the extent of change in salinity that might have occurred during the intervening period.

At the end of the study a series of permanent quadrats was established for future studies.

Samples were analysed to determine the present character and ecological history of the region. Sediment samples were analysed using the General Electric XRD 5 X-ray diffractometer. Salinity samples were determined by the use of an American Optical Company "Goldberg" refractometer, having an accuracy of 0.01 parts per thousand. The ecological character of plants and animals (whether fresh-water, brackish or marine species) was determined using data on salinity tolerance of the respective species by Hedgpeth (1953), Gunter (1938, 1945, 1950), Reid, (1954), Springer and Woodburn (1960), Tabb and Manning (1961), Chipman (1959) Kilby (1955), Kilby and Caldwell (1955) and Simpson and Gunter (1956).

The depth of the periphyton zone, used in constructing the topographic map, was determined by taking an average of 45 separate measurements of this zone at each station from an area roughly 100 yards square.

The sampling stations were located at half-mile intervals along north south transects. The transects were spaced two miles apart, beginning one quarter mile east of the intersection of the east-west leg of the Park boundary and U. S Highway Number 1. On one transect, number 5, stations were established at one mile intervals north along the north-south leg of the Park boundary and extending north to the Park entrance road (Florida Highway 27). This transect crosses the Taylor Slough

depression just south of the east end of the Park air strip at Pine Island Maintenance Area. Station 5 on this north-south transect is of special interest since it is located at the west end of a spur canal from Aerojet General's main testing facility. This canal was probably dug to drain surplus water into Taylor Slough.

TREATMENT OF THE DATA

As shown above, several specialists were engaged in the collection and analysis of various kinds of data. This work was performed independantly. The results, therefore, are as free from bias as possible.

The data have been prepared in graphic form for rapid summarization of the findings while the supporting data, species lists, X-Ray charts, etc., are available for reference if needed.

RESULTS

As a result of this study the following kinds of information are available.

1. The topography of the region. Using the height above ground level of the periphyton zone (community of lower plants forming a spongy mat) on vegetation, determination has been made of the topography of the region by converting the highest periphyton zone, indicating deepest flooding to topographic lows, and the shallowest flooding indicating topographic highs. Variations in these from station to station indicate approximate contours. This allows predictions to be made of the paths which saline water from an open canal would take over the region.

2. The salinity of water now in the region. The study was performed near the end of the dry season, so that salinities recorded are near the maximum for the year. At other times the fresh and brackish water zones would be larger than those shown in this report.

3. The distribution of the higher plants. At all stations plants were collected, identified and catagorized as to their general salinity tolerance. From the presence or absence of various plants different parts of the area can be catagorized as a freshwater, brackish water or saline region.

4. Distribution of diatoms in the periphyton. From the salt tolerance of the various species of diatoms, the different parts of the area can be similarly but independantly catagorized.

5. Distribution of the animals. From the salt tolerance of the various species of animals, the different parts of the area can again be catagorized.

6. Distribution of the sediments. Calcite sediments are deposited as a result of freshwater algal activity and chemical processes, and their presence means that an area has been a freshwater region for a long period. Aragonite sediments, with a higher magnesium content, are of marine origin.

TOPOGRAPHY AS INDICATED BY THE PERIPHYTON ZONE ON VERTICAL SURFACES

One of the greatest handicaps facing biologists and ecologists in Everglades National Park has been the absence of topographic maps. In such an area, where elevations are measured in tenths of feet, a rise in elevation of 3 to 6 inches can form a drainage divide for surface

water flow. A similarly small difference in elevation can result in an entirely different set of plants and animals than one might find in adjacent areas. Minor differences in elevation may have major implications on the water quality and depth and duration of surface flooding and therefore on the flora and fauna.

A detailed topographic map of this region has extraordinary significance in evaluating the probable effects of introducing saline water into an upland ecosystem since only by knowing the highs and lows of the ground surface will it be possible to predict the flow and deposition of saline water introduced to the area. It is vital to be able to predict where the saline water would be trapped and concentrated by evaporation. Such areas would suffer the greatest and most serious ecological alteration. It is also important to be able to predict the routes that such saline water might take in returning to the sea.

To produce such a map, measurements were made of the periphyton zone on vertical surfaces (i.e., tree trunks and mangrove roots) as an indication of the average depth of seasonal flooding. The highest zone indicates deepest flooding and the lowest land; the lowest zone indicated the shallowest water hence the highest land.

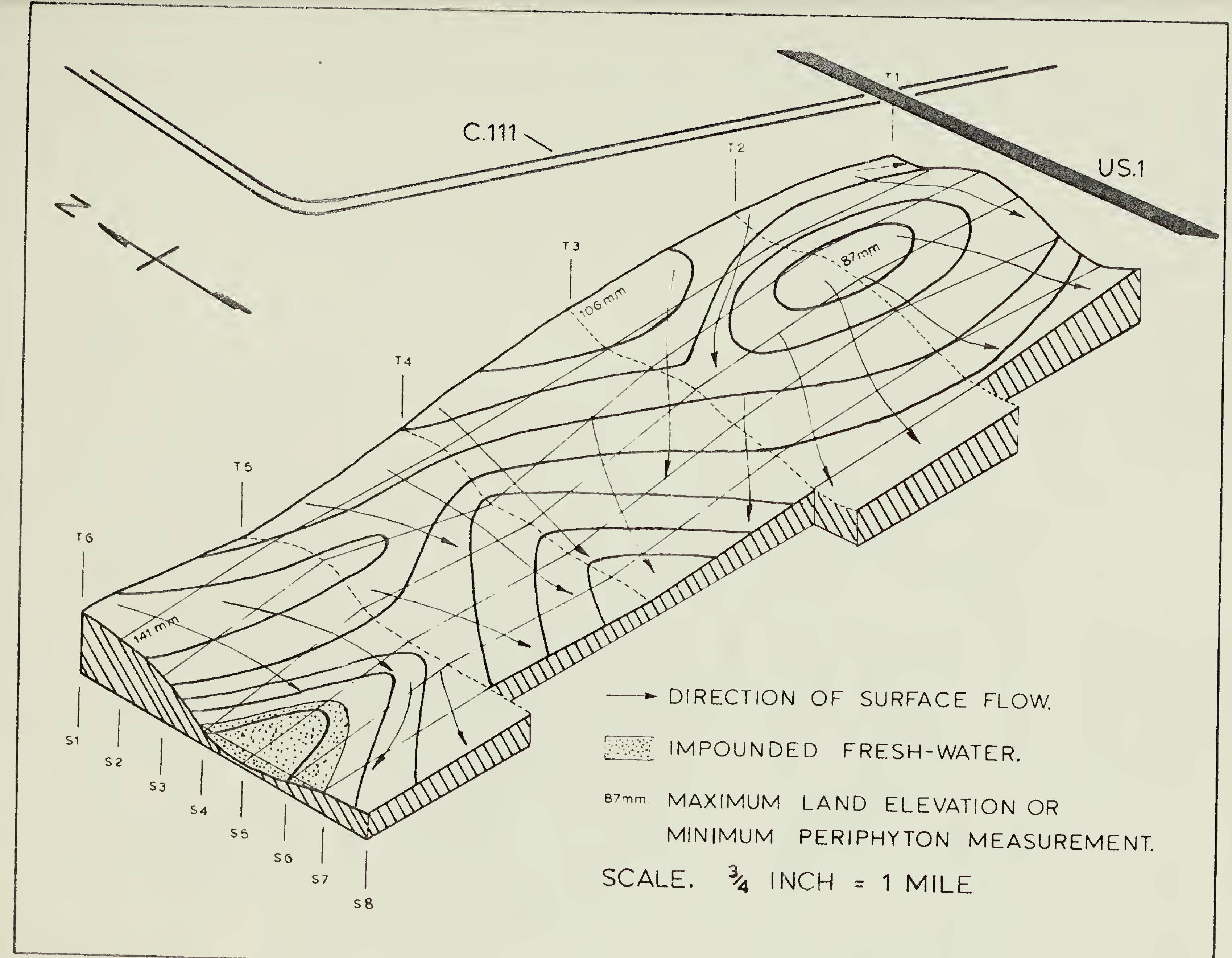
Plotting these measurements from station to station provides an approximation of the land contours.

The results of such a series of measurements have been summarized in Figure 3. The essential features of this area are as follows:

1. There are two low domes or topographic highs in the study area. One is in the eastern sector, with its center on Transect 2 between Stations 2 and 4. The second intrudes into the northwestern

Figure 3. Topography of the study area based on measurements of the high-water mark indicated by periphyton zone on plants.

Figure 3


C.111
US.1
N
T1
T2
T3
T4
T5
T6
87mm
106mm
141mm
S1
S2
S3
S4
S5
S6
S7
S8
→ DIRECTION OF SURFACE FLOW.
IMPOUNDED FRESH-WATER.
87mm. MAXIMUM LAND ELEVATION OR MINIMUM PERIPHYTON MEASUREMENT.
SCALE. 3/4 INCH = 1 MILE

corner of the study area at Transect 6, Station 1, and extends southeast to include Stations 2 and 3 of Transect 5.

2. Between these high areas there is a distinct depression which is widest along the northern shore of Joe Bay and narrowest at its apex north of Station 3 on Transect 4.

3. Another depression, the deepest, lies to the west along Transect 6. This is separated from Little Madeira Bay by a low ridge and from the depression to the east by an extension of the same ridge.

4. The maximum depth of wet season flooding, as indicated by the periphyton zone, was in the depression along Transect 6. This was 300 mm. on the average, while the greatest depth indicated in the eastern depression along Transect 4 was 251 mm. on the average.

5. Extensive impoundment of residual fresh-water (surface of a falling water table) was observed in the depression behind the coastal ridge along Transect 6. This water was deepest in the area around Station 5 and shallowest at Stations 4 and 7, which had average periphyton measurements of 279 and 251 mm. respectively. It should be noted that the deepest point in the depression centered on Transect 4 was 251 mm. at Station 5. This suggests that under rainfall and ground water conditions which were prevailing on February 16 through March 5, relatively permanent water would be found only below 251 to 255 mm., or in the depression along Taylor Slough.

6. The eastern dome is separated from Canal C-111 by a shallow depression which curves southeast and southwest around the dome. Surface water accumulating in this area from the north will therefore be diverted in both directions, some to accumulate against U.S. Highway 1 and thence into northeastern Florida Bay, the rest to flow southwest into the Joe Bay drainage. If this flow from the north is sufficient, it

will over-top the low mound and the flow will be fan-like, entering Florida Bay along the entire front between the highway and Joe Bay.

7. This interpretation of the probable water flow pattern is supported by the alignment of the natural sloughs. These are clearly seen on aerial photos of the region and conform to the direction of flow suggested by the topographic map (Figure 3).

8. There is southeasterly drainage of fresh-water into the western sector of the study area from a topographic high located north of Transects 5 and 6. This high is crossed along Transect 5 north (Figure 2) in the vicinity of Station 3N and the area drops from there into the main Taylor River depression, which drains south-southwest. From Station 3N drainage is fan-wise, northwest-west-southwest-south to southeast. Surface water flows into the vicinity of Station 1N, 2N and 3N from Aerojet General property to the northeast and it would be under the influence of saline water spill-over from Canal C-111 should such spill be extensive as during the Autumn Equinox.

9. The maximum difference in elevation between the highest and lowest point in the study area was 216 mm (i.e., 8.~~64~~5 inches) in the southern sector.

The ecological relationships are so intricate that smaller changes in elevation than this govern the kinds and abundance of plants, the duration of flooding, and the inland penetration of sea water during storms. With such small irregularities in the study area it is clear that water must flow seaward very slowly, and seawater spill-over would be retained on land surface for prolonged periods.

SALINITY

Surface salinity conditions that existed during the period February 16 through March 7 are summarized in Figure 4, and the data are presented in Table 1. The stippled area indicated biologically effective freshwater (0.0 to 5.0 parts per thousand). The other isohalines are indicated.

The fresh-water zone (0.0 to 5.0 parts per thousand) covers 35.6 per cent of the study area; the lower brackish-water zone (5.0 to 10.0 parts per thousand) covers 19.5 per cent; the upper brackish-water zone covers 28.2 per cent; the low-marine salinity (greater than 20.0 parts per thousand) covers the remaining 16.7 per cent.

Surface water in the sawgrass and Eleocharis marl flats will disappear, due to evapo-transpiration, over much of the fresh-water area before the spring rains occur. However, there is sufficient water in the deeper sloughs and "gator holes" to support a reduced population of breeding animals until the rainy season commences in late April or May.

Because of the efficient seal formed by the marl in this region, and the low relief, it will take only a short time after the spring rains fall to flood the area with fresh water once again. The distribution of salinity described here should be, therefore, considered as near maximum values for years of normal to somewhat higher than normal rainfall as 1966-67.

It is important to note that were the plug to be removed from Canal C-111, water in excess of 20 parts per thousand would immediately enter the reach of the canal west of Highway 1 and north of the Park boundary.

Figure 4: Distribution of salinity in the study area during the period February 16 through March 7, 1967 near the end of the dry season.

Figure 4

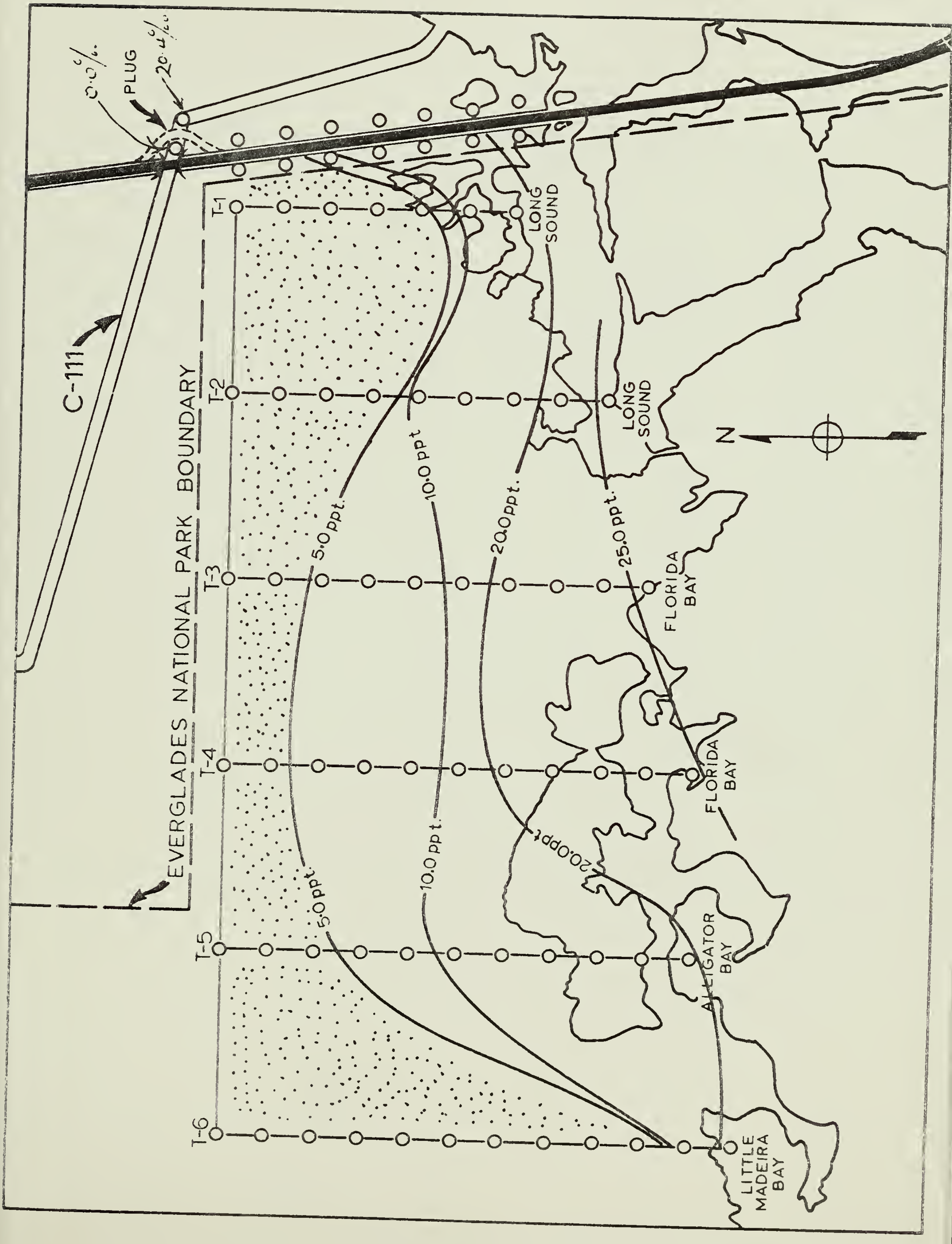

0.0‰
PLUG
20.4‰
C-111
EVERGLADES NATIONAL PARK BOUNDARY
T-1
T-2
T-3
T-4
T-5
T-6
LONG SOUND
LONG SOUND
N
5.0 ppt.
10.0 ppt
20.0 ppt.
25.0 ppt.
FLORIDA BAY
FLORIDA BAY
10.0 ppt.
20.0 ppt
FLORIDA BAY
5.0 ppt.
10.0 ppt.
ALLIGATOR BAY
LITTLE MADEIRA BAY

Table 1: Salinity values obtained during the period February 16 - March 10, 1967 in parts per thousand.

	Transects							
Station	6	5	4	3	2	1	West side U.S.1	East side U.S.1
1	0.0	0.0	1.8	0.0	0.0	0.0	0.0	20.4
2	0.0	0.9	1.8	2.6	0.0	0.0	1.0	15.5
3	0.0	3.3	12.1	7.2	0.0	0.0	10.8	23.8
4	0.0	8.0	5.0	9.7	4.2	0.0	11.5	26.0
5	0.0	8.9	8.0	6.6	15.6	0.0	12.3	26.8
6	0.0	11.4	13.0	10.4	13.3	10.0	12.3	27.6
7	0.0	16.2	22.0	22.0	13.3	15.6	14.0	28.4
8	0.0	9.7	19.3	22.0	21.2	22.0	21.2	28.4
9	1.2	17.8	19.3	22.0	26.0			
10	2.6	17.8	19.3	27.4				
11	10.4	19.3	24.2					
12	22.6							

Under those conditions, and given high water due to lunar and east wind tides, there would be spill-over of this near-marine water onto the Park. The swale topography indicated in Figure 3 would lead the water east and west, to eliminate approximately half the freshwater area indicated. This would kill the salt-sensitive plants, and would thus alter the character of the region affected just as hurricane Betsy did north of the C-111 canal. Kills of fresh water and brackish water animals would follow.

DISTRIBUTION OF ANIMALS

During this study 63 species of crustaceans, mollusks, fishes, aquatic insects, reptiles and amphibians were collected. These have been designated as fresh-water, brackish or marine in character. This determination is based on the published opinions of several estuarine ecologists (see Introduction) (Table 2). The occurrence of the fresh-water, brackish water and marine species is summarized in Figure 5. Fresh-water species, (i.e., species that breed only in fresh-water environment) occupied 60.0 per cent of the area surveyed, brackish water species occupied 24.8 per cent, and marine species the remaining 15.2 per cent.

The area of salinity between 0.0 and 5.0 parts per thousand (Figure 4) is the only area where bass, sunfish and the killifishes, *Fundulus chrysotus* and *Lucania goodei*, will be found. It is also the only area where living apple snails, *Ampularia depressa*, and the ramshorn snail, *Heliosoma duryi*, will occur and reproduce. Seaward of this is the zone of 5.0 to 10.0 parts per thousand where the mosquitofish, *Gambusia affinis*, and mollies, *Mollienesia latipinna*, are found in greatest abundance, and where the indicator species of shrimp, *Palaemonetes paludosus*, is replaced by the brackish water species *P. intermedius*.

Table 2. List of species collected during the period February 16 through March 7, 1967 with notation as to habitat based on salinity tolerance.*

Crustaceans	Mollusks	Fishes
Procambarus alleni FR-BR	*Ampularia depressa* FR	*Gambusia affinis* FR-BR
Palaemonetes intermedius BR	*Pseudocyrena floridana* FR-BR	*Fundulus confluentus* BR-FR
Palaemonetes paludosus FR	*Tagelus plebius* MAR	*Mollienesia latipinna* FR-BR
Callinectes sapidus MAR BR-FR	*Melongena corona* MAR-BR	*Jordanella floridae* FR
Uca speciosa BR-MAR	*Cerithidea scalariformis* FR-BR	*Strongylura* sp. BR-MAR
Uca pugilator BR-MAR	*Cerithidea costata* BR-MAR	*Dormitator maculatus* BR-FR
Sesarma reticulatum BR-MAR	*Anomalocardia cunimeris* BR-MAR	*Gobiosoma robustum* BR-MAR
Ligia baudiniana MAR	*Polymesoda floridana* FR-BR	*Microgobius gulosus* BR-MAR
Ligia exotica MAR-BR	*Physa* sp. FR	*Lucania parva* BR-MAR
Hippolyte pleuracantha MAR-BR	*Ostrea virginica* BR-MAR	*Lucania goodei* FR
Thor sp. MAR	*Brachidontes recurvus* BR-MAR	*Micrognathus crinigerus* MAR
Alpheus normanni MAR-BR	*Melampus coffeus* BR-MAR pulmonate	*Lophogobius cyprinoides* BR-MAR
Neopanope t. texana MAR-BR	*Melampus bidentatus* BR-MAR	*Jordanella floridae* FR-BR
Neopanope packardii MAR-BR	*Brachidontes exustus* BR-MAR	*Floridichthys carpio* BR-MAR
Rithropanopeus harrisii FR-BR	*Modulus modulus* MAR	*Gobiesox strumosus* BR-MAR
Cyathura polita MAR-BR	*Aequipecten irradians* MAR	*Floridichthys chrysopterus* FR
Eurypanopeus depressus MAR-BR	*Prunum apicinum* BR-MAR	*Lepomis punctatus* FR-BR
	Bulla striata BR-MAR	*Lepomis macrochirus* FR
	Helisoma duryi FR	*Lepomis microlophus* FR
		Micropterus salmoides FR
Miscellaneous		*Fundulus grandis* FR-BR
Hyla cinerea FR		*Ictalurus melas* FR
Rana pipiens sphenocephala FR-BR		*Lepisosteus platyrhincus* FR-BR
Ancistrodon p. piscivorous FR		
Crotalus adamantus FR-BR		

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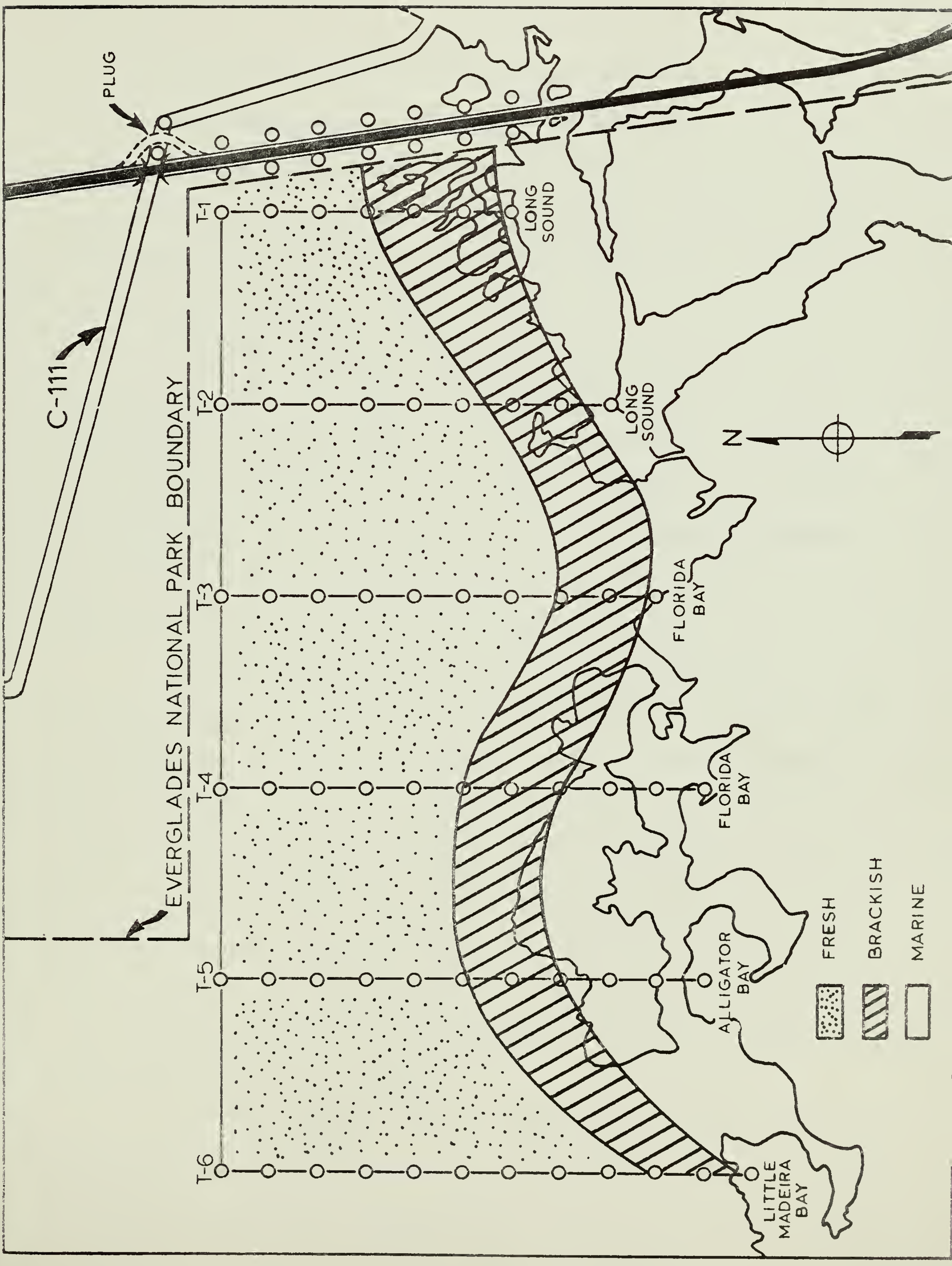
* In many cases a species can survive a range of conditions (i.e., fresh-water gar in brackish water) but are not normally brackish-water inhabitants. Such species are indicated above by the letter combination FR-BR. The FR indicates the normal habitat in which the populations reproduce and survive to reproduce again.

Figure 5: Distribution of fresh-water, brackish and marine animals during the period February 16 through March 7, 1967.

Figure 5


PLUG
C-111
EVERGLADES NATIONAL PARK BOUNDARY
T-1
T-2
T-3
T-4
T-5
T-6
LONG SOUND
LONG SOUND
FLORIDA BAY
FLORIDA BAY
ALLIGATOR BAY
LITTLE MADEIRA BAY
N
FRESH
BRACKISH
MARINE

Some animals which are acknowledged fresh-water species, such as the Florida gar, *Lepisosteus platyrhincus*, may be driven into brackish waters by a falling water table. Under such stress conditions the species can live for a while in salinity of 9 to 10 parts per thousand, perhaps even higher for short periods, but this in no way changes the fact that this is a true fresh-water species.

Successful spawning is probably the best indication of the habitat selection of the species, and this information must be used in determining the "normal" habitat. Some of the sunfishes, for example, can tolerate salinity between 4 to 5 parts per thousand, but none spawn in such salinity. Some of the killifishes (e.g.*Cyprinodon variegatus*) have a wide salinity tolerance as advanced juveniles and adults but they spawn in the marshes during periods of high surface water and low salinity.

Such knowledge was considered in making the decision as to the "habitat preference" of species which occurred in areas of habitat overlap as between fresh and brackish water. There was one complicating factor, that of predation by birds. Such predation reaches a peak during this dry time of the year and reduced pools of water are being rapidly fished out. Many of the pools visited by the field parties were surrounded by flocks of ibises, egrets and other wading birds. This resulted in a minimal collection of larger fishes; recent kills of sunfish and bass by predators were found on the banks surrounding a number of sloughs and seismic craters, the latter along the park boundary.

On the basis of the evidence gathered during this study, the Taylor Slough depression and the deep solution holes in the Miami oolite in the high ground north of the heads of Transects 4, 5, and 6 are a major

focal point for survival of aquatic organisms of fresh water during drought. This corresponds closely with the area of dwarf cypress coverage. If this region were denied sufficient surface water during drought to permit at least some survival of aquatic animals, it is doubtful that recovery of populations by immigration would take place in the region south of Canal C-111. In addition, if saline water were permitted to move overland and then to spill down gradient into the Joe Bay and Taylor River depressions, it would effectively block the eastward movement of fresh water organisms and destroy the slough "moats" and "gator-hole" environment which characterizes the habitat of the fresh water animals in this region.

HIGHER PLANTS

Collections of higher plants were made on Transects 1, 2, 3, and 5 (Figure 2); all stations along these transects were included except 5, 6 and 7 on Transect 1, and 9 on Transect 5 which was in Joe Bay. Transect 4 was omitted except for Station 1, where salt-sensitive plants were located.

Air observation prior to landing at each station permitted a decision to be made as to which areas of surrounding marl habitat and hammocks should be examined.

Sawgrass, *Mariscus jamaicensis*, and spike rush, *Eleocharis cellulosa*, culms in 20 one-meter square quadrats were counted. The hammocks were traversed at least through one diameter, and sampling was also done on the perimeter as necessary to make an adequate plant list (Appendix Tables 1-4). Data from the 20 one-meter square marl quadrats

are reported as frequency, density and abundance (Table 3)with definition of the three terms as follows:

Frequency--the percentage of quadrats occupied by a given species

Density--the average number of culms of a species per quadrat

Abundance--the average number of individuals of a species per quadrat of occurrence.

Special attention was given to the occurrence and condition of species that in the hurricane Betsy study had been found to be salt-sensitive, and to have been killed or damaged. The current study area overlaps a part of the hurricane study area. Several different plant associations were examined in the study of the distribution of freshwater and saline species.

CHARACTERIZATION OF THE HABITAT BY VEGETATION TYPES PRESENT

Based on the 25 year experience by Alexander in the plant ecology of the low hammocks of the area, species which are characteristic of the fresh water and salt water habitats of the area are known. These species were noted as each transect was worked from north to south. The fresh water oriented species encountered include the following:

Pond apple	*Annona glabra*
	Calyptranthes pallens
Buttonbush	*Cephalanthus occidentalis*
Cocoplum	*Chrysobalanus icaco*
	Eugenia axillaris
Strangler fig	*Ficus aurea*
Holly	*Ilex cassine*
Sweet bay	*Magnolia virginiana*
Poisonwood	*Metopium toxiferum*
Wax myrtle	*Myrica cerifera*
Red bay	*Persea borbonia*
Marlberry	*Rapanea guianensis*
Cypress	*Taxodium distichum*
Grape	*Vitis munsoniana*

Table 3. Frequency, density and abundance of sawgrass and Eleocharis 20 one meter square quadrats from marl areas.

Transect and Station	Frequency % Sawgrass	 Eleocharis	Density Sawgrass	 Eleocharis	Abundance Sawgrass	 Eleocharis
T 1-1	95	50	8.1	32.1	9.0	64.3
2	95	95	7.0	24.8	7.4	26.2
3	5	100	0.4	47.5	7.0	47.5
4	similar					
T 2-1	95	25	6.8	8.8	7.1	35.2
2	100	5	9.9	0.2	9.9	4.0
3	80	95	1.9	32.2	2.4	32.2
4	70	65	2.3	27.0	3.3	41.8
5	0	95	0.0	21.7	0.0	22.8
6	0	95	0.0	-	0.0	few
7	bare	bare	0.0	-	0.0	0.0
T 3-1	95	55	10.7	1.3	11.4	2.4
2	95	55	10.7	2.2	11.4	4.0
3	90	60	11.1	10.3	12.3	16.9
4	45	95	2.2	33.5	4.9	32.0
5	0	80	0.0	13.2	0.0	16.6
6	0	similar	0.0	-	0.0	-
7	0	similar	0.0	-	0.0	-
8	0	100	0.0	thick	0.0	thick
9	bare	bare	0.0	0.0	0.0	0.0
T 5-1	100	15	11.2	1.4	11.2	9.3
2	100	70	14.8	6.9	14.8	9.9
3	95	100	11.5	30.6	12.1	30.6
4	0	100	0.0	thick	0.0	thick
5	0	100	0.0	thick	0.0	thick
6	0	few	0.0	thin	0.0	thin
7	0	few	0.0	thin	0.0	thin
8	0	100	0.0	thick	0.0	thick
9	--	--	--	--	--	
10	0	0	0.0	0.0	0.0	0.0

The vegetation data have been interpolated across the stations on Transect 4, stations 2-11. It is felt that the lines as drawn fairly represent the situation on Transect 4. Aerial observation, and the fact that most of the other parameters measured indicate rather smooth and uniform curve-locations between transects 3 and 5, both of which were checked, suggests that this interpolation is justified.

(a) Figure 6, Area A, shows the distribution of the low hammocks where fresh-water plants occurred. Various mixtures of the species listed above as fresh-water types occurred there. All hammocks visited had buttonwood and red mangrove present. The former species is more abundant in the hammocks to the north where fresher water occurs. It has been well established that buttonwood and red mangrove are both fresh and salt water tolerant. Area B indicates the extent of coverage of low hammock growth having a predominance of salt-tolerant species and few of the salt-sensitive species listed above.

(b) Figure 7 shows the approximate location of a mixed sawgrass-*Eleocharis* belt, with a pure *Eleocharis* belt south of it. In areas north of C-111 which had been inundated by hurricane Betsy, sawgrass and *Eleocharis* stands were selectively killed by the saline water; sawgrass tended to die out and *Eleocharis* spread rapidly. This evidence, added to the distribution found on the transects, indicates that the sawgrass-*Eleocharis* belt to the north is fresh water oriented. The fact that *Eleocharis* is replaced by salt grass, *Distcholis spicata*, to the south indicates that *Eleocharis* is occupying an intermediate zone between fresh and salt water influences.

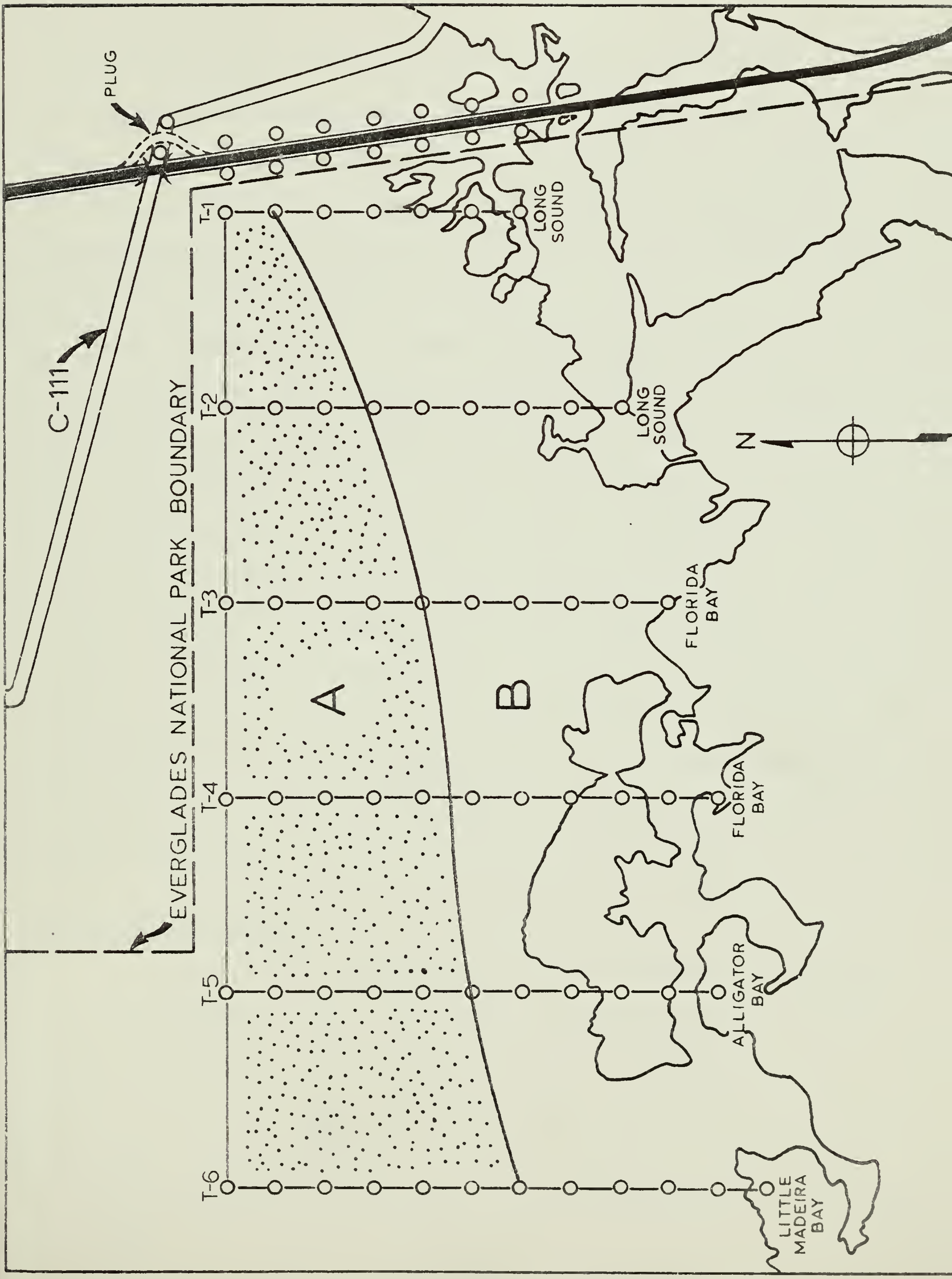
(c) Figures 8 through 14 show the distribution of seven species of plants considered to be fresh water-oriented. It is likely that

Figure 6. Characterization of the habitat based upon vegetation types.

Area A. Low hammocks primarily with fresh-water species.

Area B. Low hammocks with salt tolerant species more abundant.

Figure 6


PLUG
C-111
EVERGLADES NATIONAL PARK BOUNDARY
T-1
T-2
T-3
T-4
T-5
T-6
LONG SOUND
LONG SOUND
FLORIDA BAY
FLORIDA BAY
ALLIGATOR BAY
LITTLE MADEIRA BAY
A
B
N

cocoplum, wax myrtle, marlberry, red bay, and grape all occurred in Transect 1-Station 2 before hurricane Betsy. Seedlings of most of these have appeared in Transect 1-Station 1 and likely will appear in Transect 1-Station 2 in the future. In any event, as one progresses westward from U.S. 1 these species all occur as a part of the Park flora and tend to occupy more southerly sites.

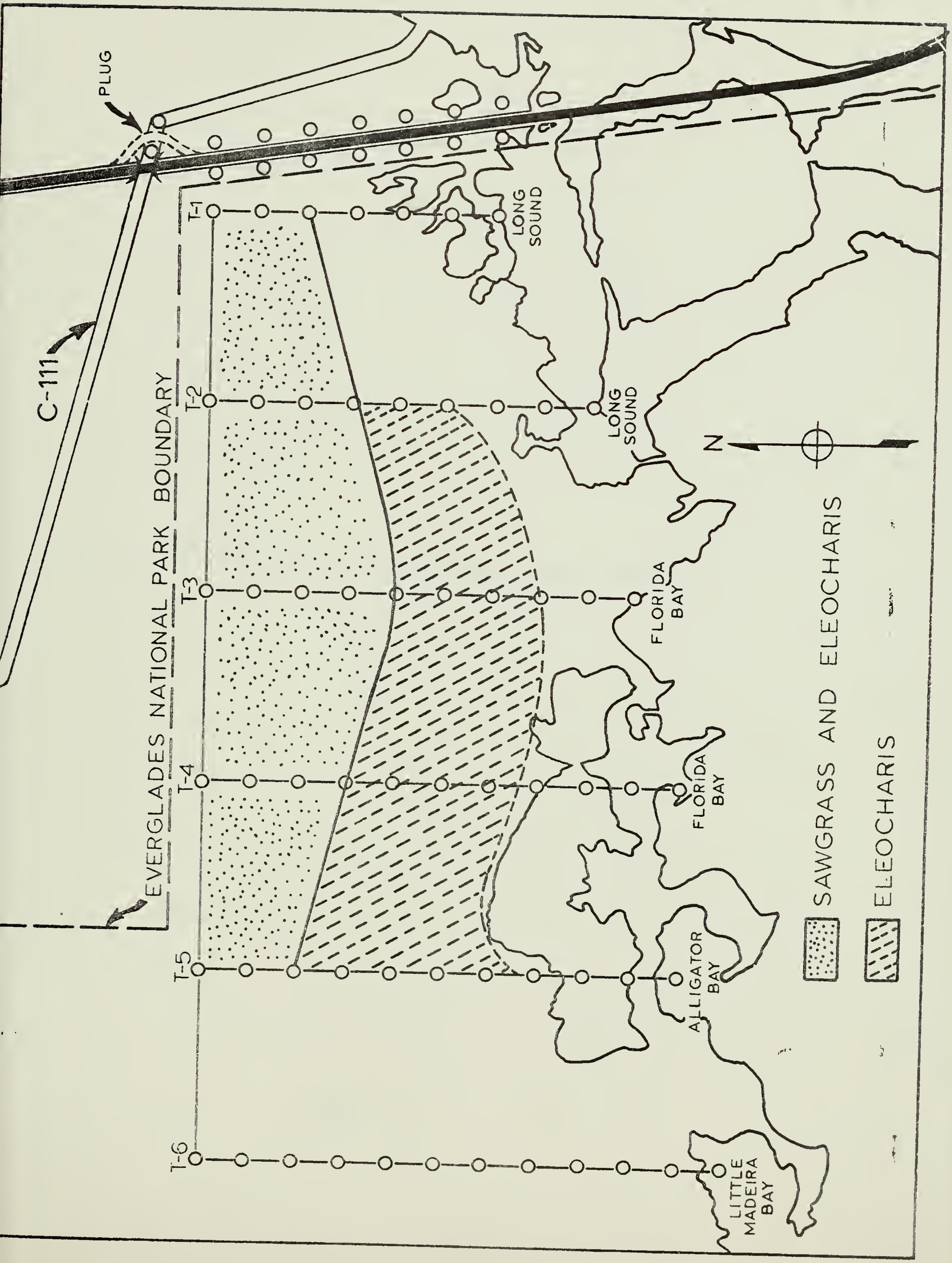
If this habitat is changed to one of higher salinities, the species mentioned above as fresh water oriented will tend to disappear. Examination of the hammocks nearer C-111, north of C-111 and east of U.S. 1 will show what happens to these species when salt water reaches their habitat. Under saline influence, a shift in hammock type could be expected, with mangroves and buttonwoods crowding out the other hammock species. Likewise, the Eleocharis belt would probably expand at the expense of the sawgrass-Eleocharis belt. Coupled with this would be a decrease in the area covered by the algal mat that reaches its peak development in the sawgrass-Eleocharis belt. All of these changes would instigate shifts in cover and food supply from those that exist under present conditions.

DISTRIBUTION OF DIATOMS

In the Florida Everglades one of the most important communities is a thick "periphyton mat" which covers the ground and grows attached to the stems of plants. It is composed of interwoven strands and single cells of microscopic algae, principally diatoms, and precipitated calcium carbonate. It has an important role in the production of organic and inorganic soils and in the food chain. It is indispensable as food for the herbivores.

Figure 7. Location of the sawgrass - _Eleocharis_ belts.

Figure 7



PLUG
C-111
EVERGLADES NATIONAL PARK BOUNDARY
T-1
T-2
T-3
T-4
T-5
T-6
LONG SOUND
LONG SOUND
FLORIDA BAY
FLORIDA BAY
ALLIGATOR BAY
LITTLE MADEIRA BAY
N
SAWGRASS AND ELEOCHARIS
ELEOCHARIS

Figure 8. Distribution of Chrysobalanus icaco (cocoplum).

Figure 8

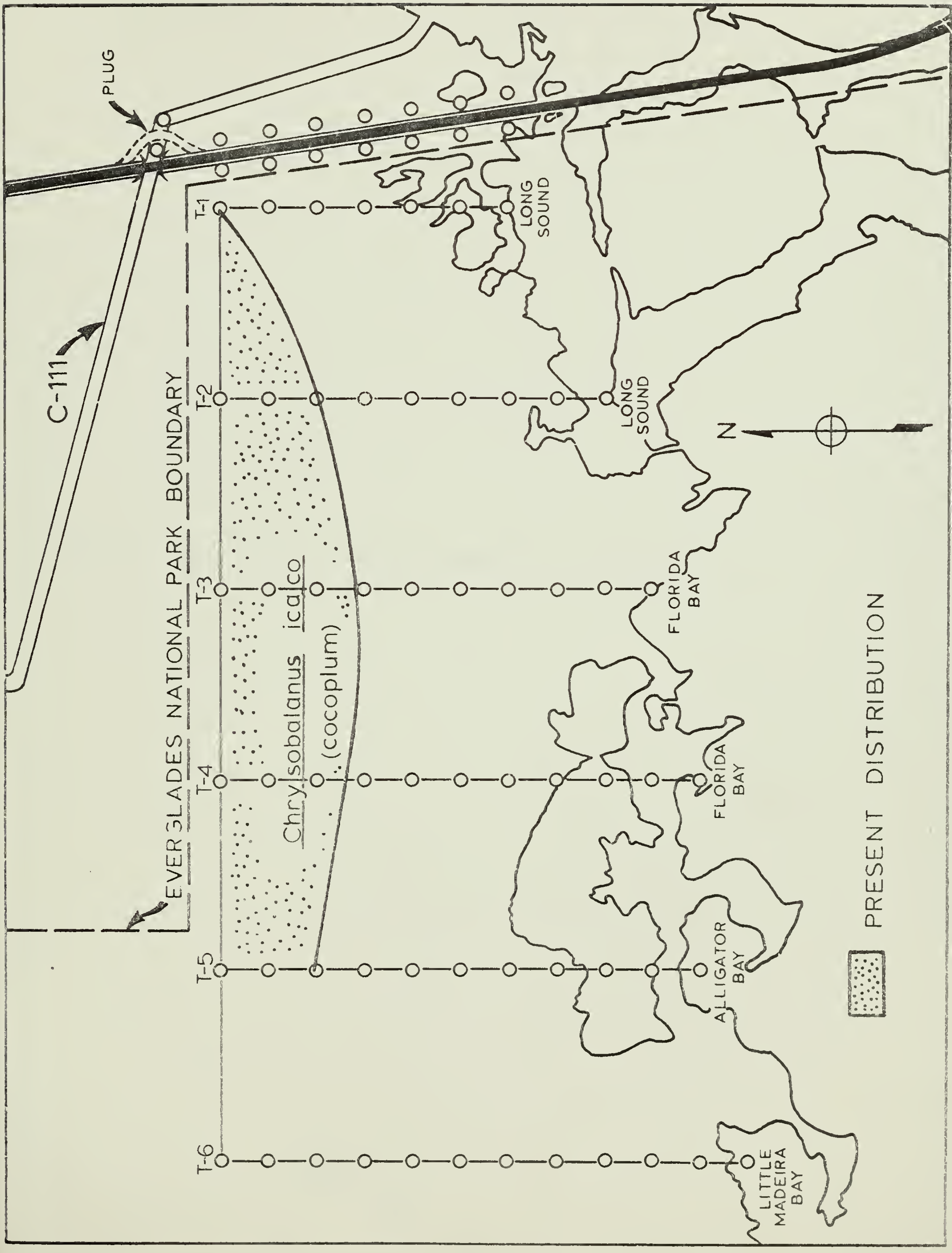

PLUG
C-111
EVERGLADES NATIONAL PARK BOUNDARY
T-1
T-2
T-3
T-4
T-5
T-6
LONG SOUND
LONG SOUND
FLORIDA BAY
FLORIDA BAY
ALLIGATOR BAY
LITTLE MADEIRA BAY
Chrysobalanus icaco
(cocoplum)
N
PRESENT DISTRIBUTION

Figure 9. Distribution of *Myrica cerifera* (wax myrtle).

Figure 9

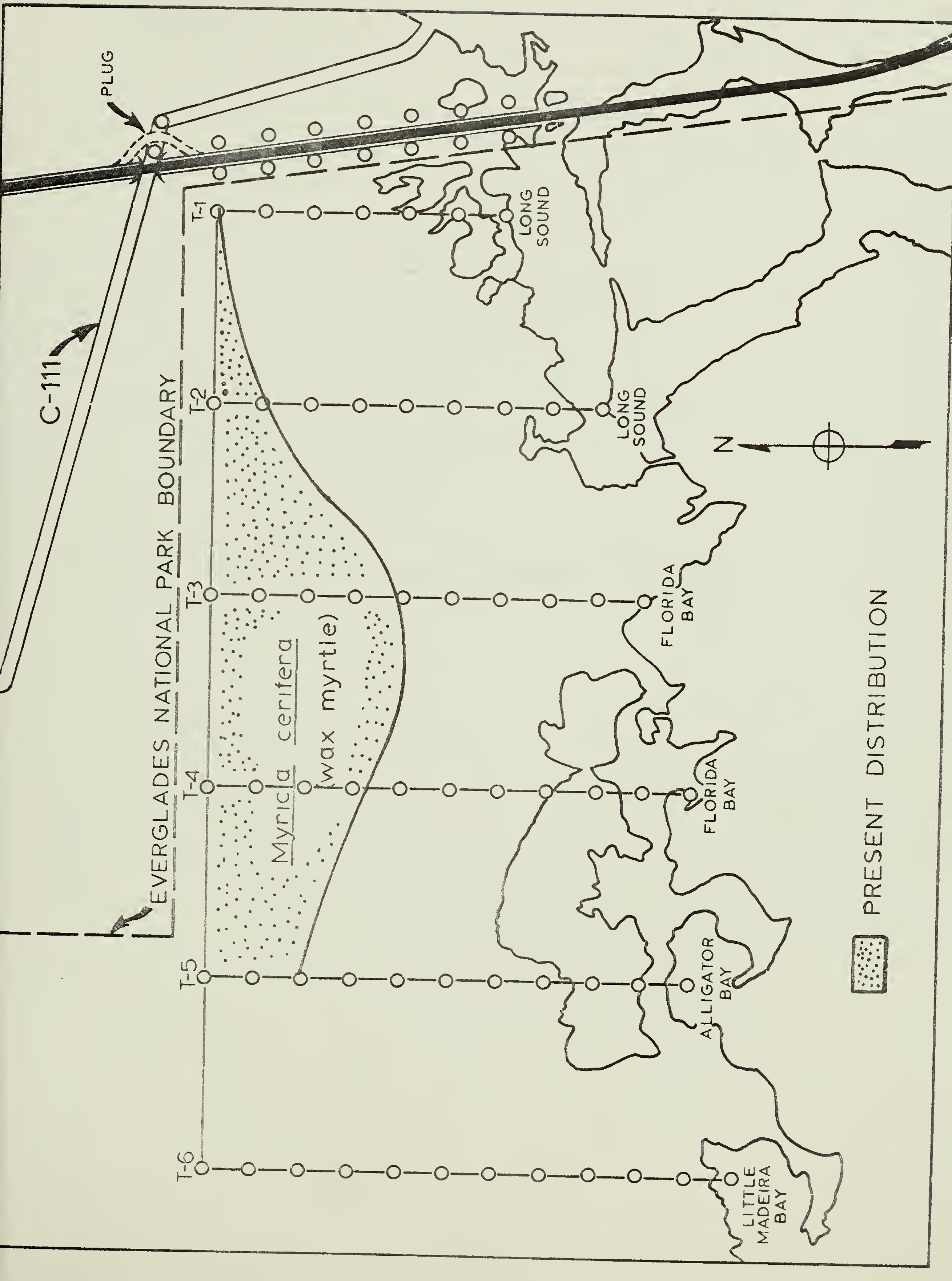

PLUG
C-111
EVERGLADES NATIONAL PARK BOUNDARY
T-1
T-2
T-3
T-4
T-5
T-6
LONG SOUND
LONG SOUND
N
FLORIDA BAY
FLORIDA BAY
ALLIGATOR BAY
LITTLE MADEIRA BAY
Myrica cerifera
(wax myrtle)
PRESENT DISTRIBUTION

Figure 10. Distribution of *Rapanea guianensis* (marlberry).

Figure 10

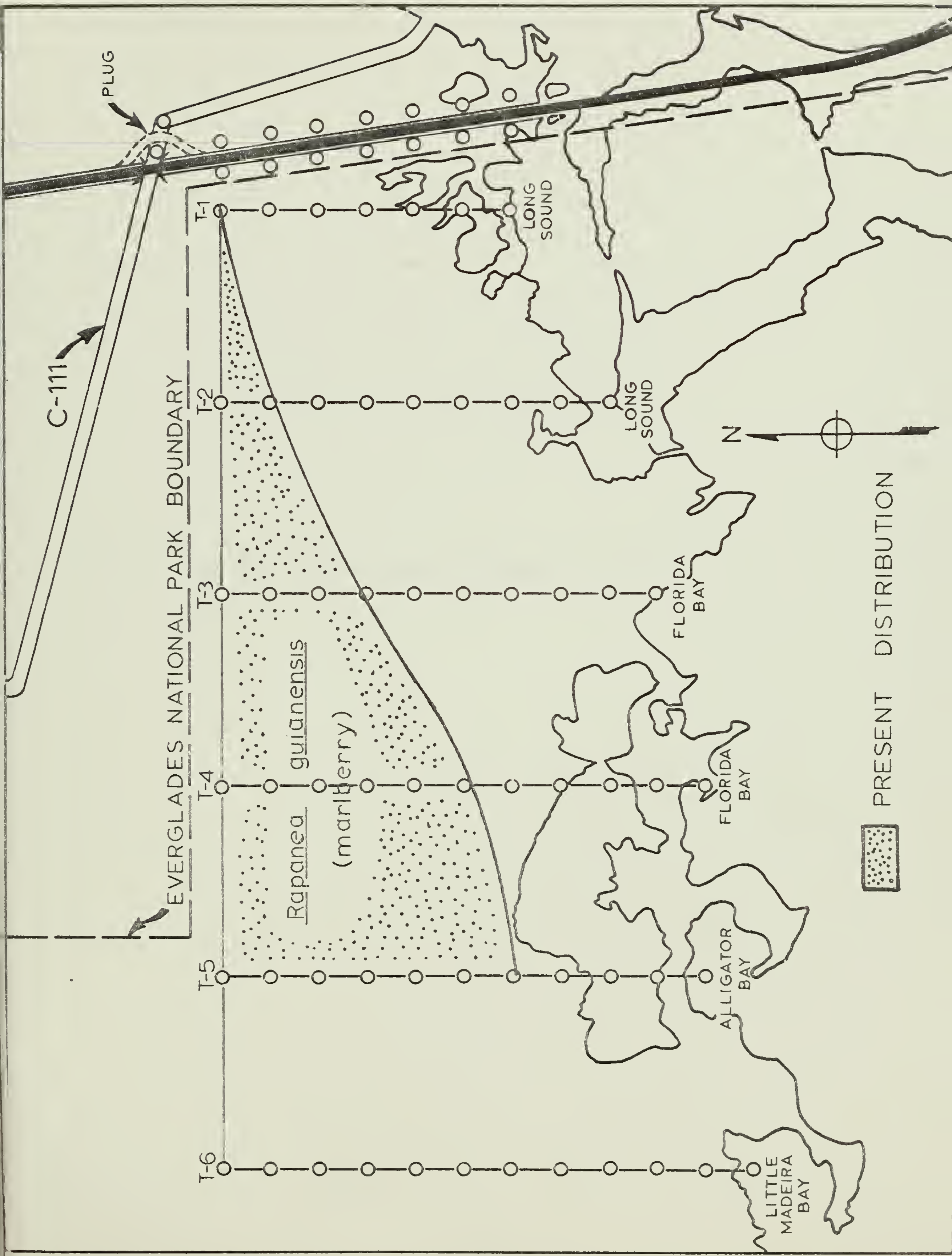

PLUG
C-111
EVERGLADES NATIONAL PARK BOUNDARY
T-1
T-2
T-3
T-4
T-5
T-6
LONG SOUND
LONG SOUND
FLORIDA BAY
FLORIDA BAY
ALLIGATOR BAY
LITTLE MADEIRA BAY
Rapanea guianensis
(marlberry)
N
PRESENT DISTRIBUTION

Figure 11. Distribution of *Persea borbonia* (red bay).

Figure 11

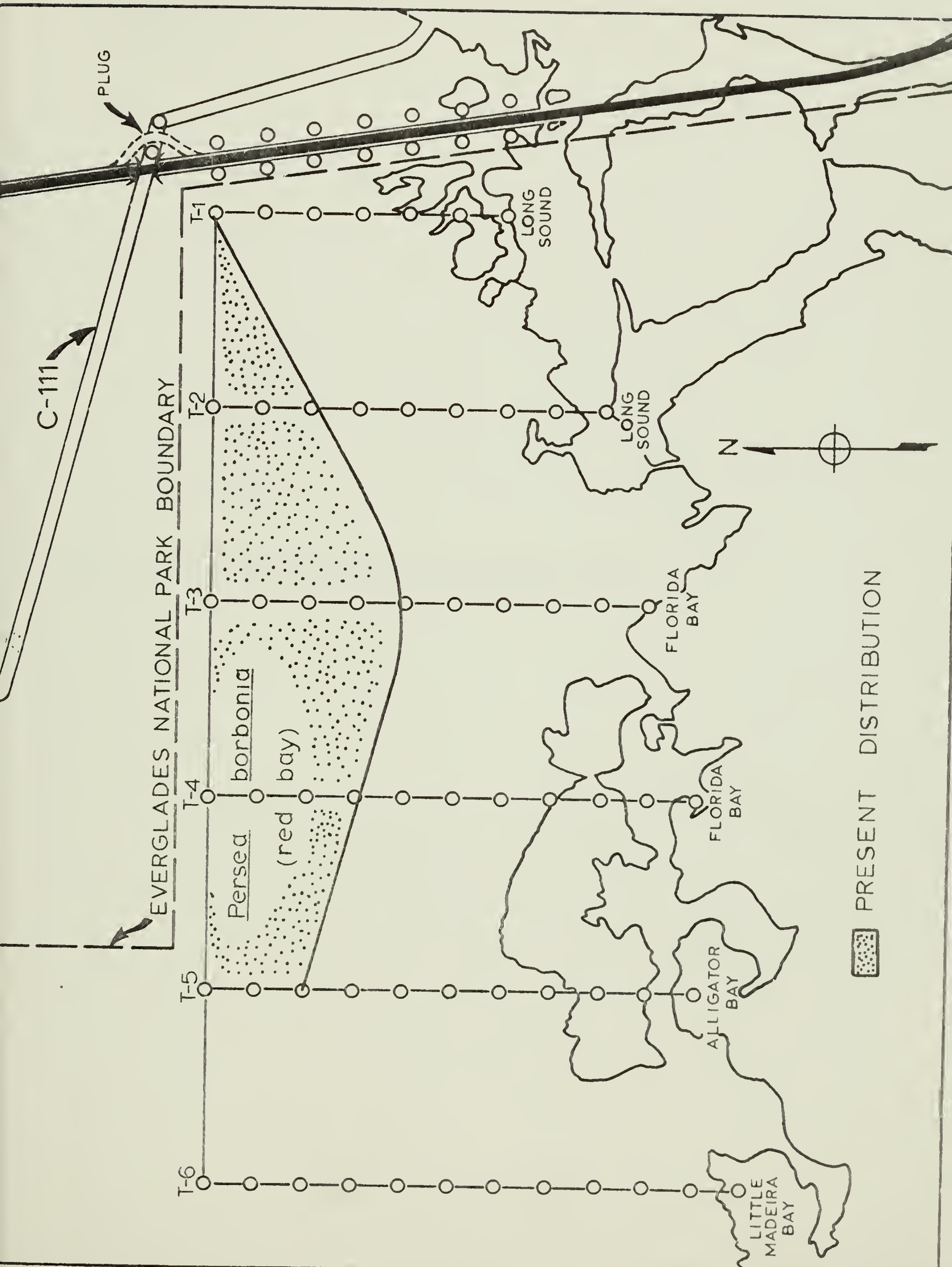

PLUG
C-111
EVERGLADES NATIONAL PARK BOUNDARY
T-1
T-2
T-3
T-4
T-5
T-6
LONG SOUND
LONG SOUND
FLORIDA BAY
FLORIDA BAY
ALLIGATOR BAY
LITTLE MADEIRA BAY
N
Persea borbonia
(red bay)
▨ PRESENT DISTRIBUTION

Figure 12. Distribution of Vitis munsoniana (grape).

Figure 12

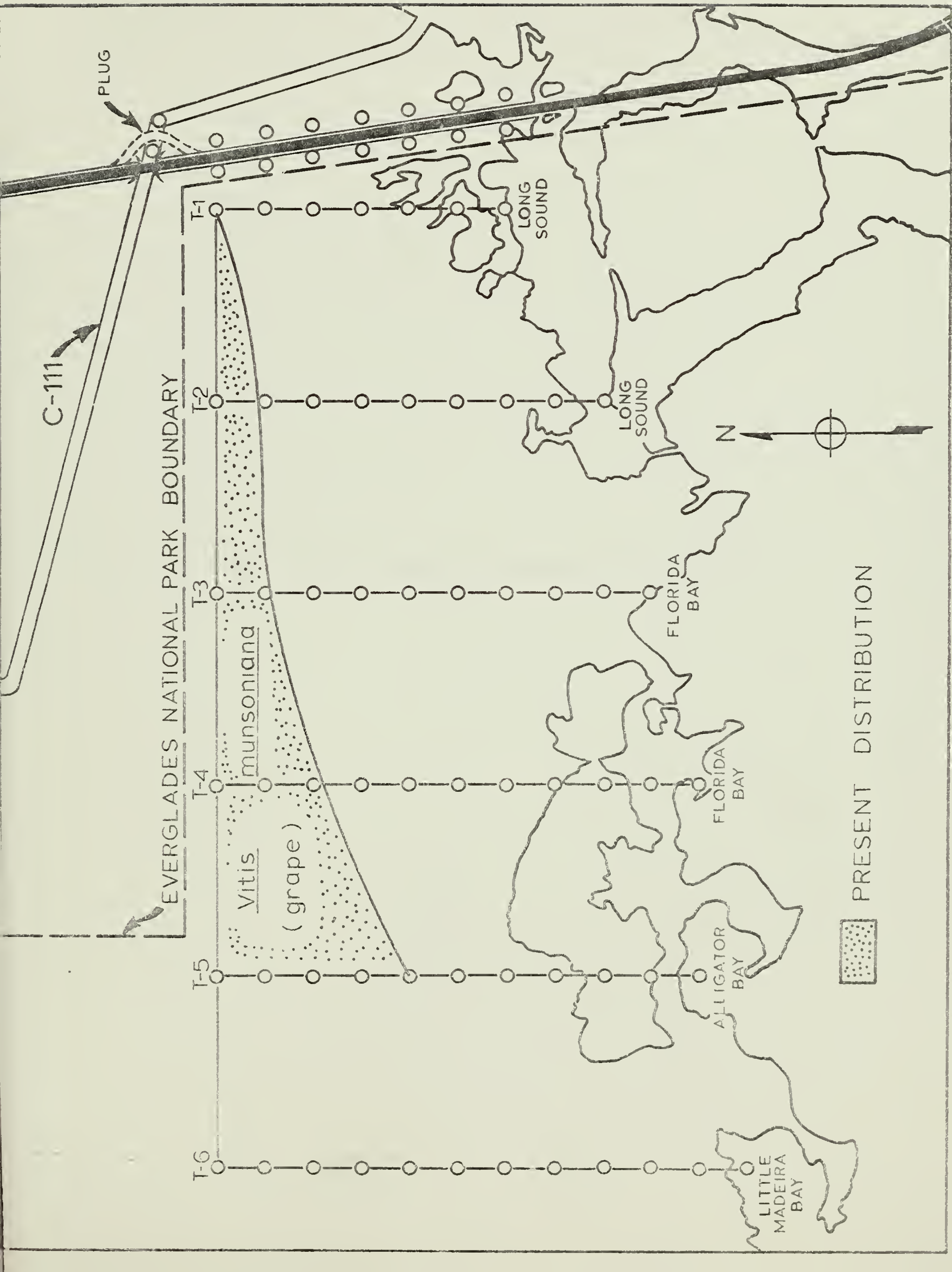

PLUG
C-111
EVERGLADES NATIONAL PARK BOUNDARY
T-1
T-2
T-3
T-4
T-5
T-6
LONG SOUND
LONG SOUND
FLORIDA BAY
FLORIDA BAY
ALLIGATOR BAY
LITTLE MADEIRA BAY
N
Vitis munsoniana
(grape)
PRESENT DISTRIBUTION

Figure 13. Distribution of *Metopium toxiferum* (poison wood).

Figure 13

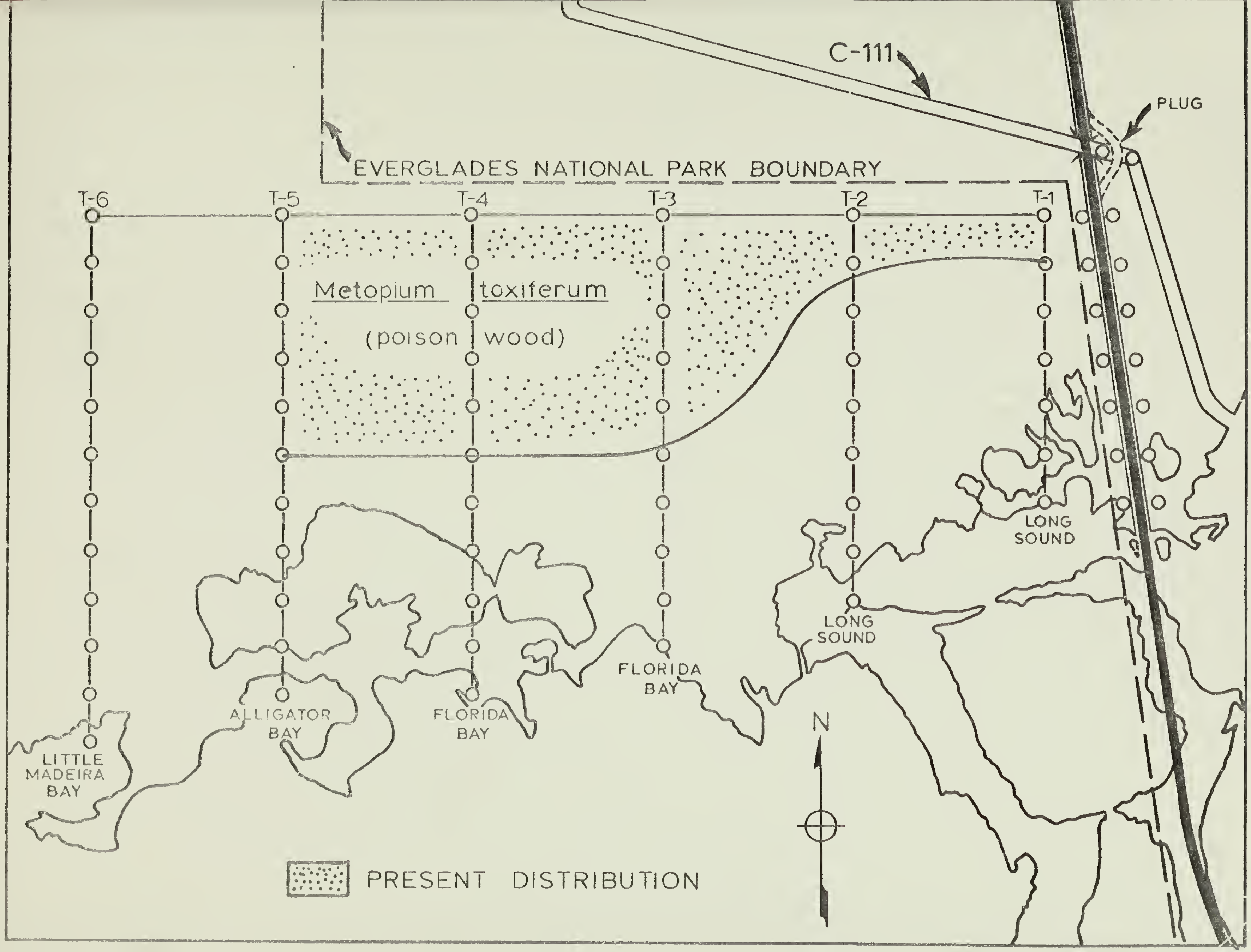
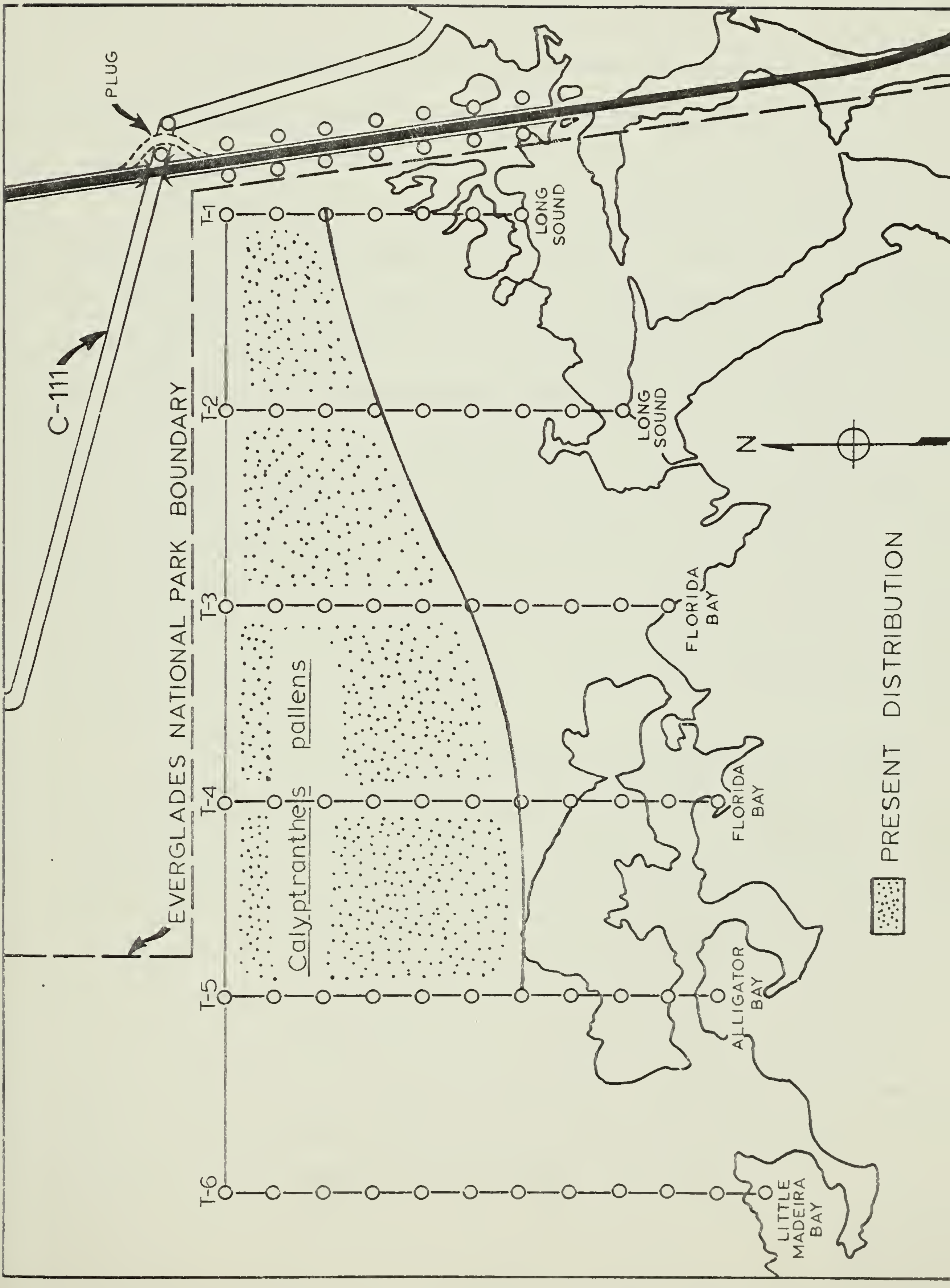

C-111
PLUG
EVERGLADES NATIONAL PARK BOUNDARY
T-6
T-5
T-4
T-3
T-2
T-1
Metopium toxiferum
(poison wood)
LONG SOUND
LONG SOUND
FLORIDA BAY
FLORIDA BAY
ALLIGATOR BAY
LITTLE MADEIRA BAY
N
PRESENT DISTRIBUTION

Figure 14. Distribution of Calyptranthes (pallens).

Figure 14


PLUG
C-111
EVERGLADES NATIONAL PARK BOUNDARY
T-1
T-2
T-3
T-4
T-5
T-6
LONG SOUND
LONG SOUND
FLORIDA BAY
FLORIDA BAY
ALLIGATOR BAY
LITTLE MADEIRA BAY
Calyptranthes pallens
N
PRESENT DISTRIBUTION

The periphyton mat of the study area was examined for its diatoms. From known salinity tolerance of the species they can be categorized.

The species found at each station are enumerated in Appendix Tables 5-11. Those species which are indicators of fresh water, brackish and saline conditions are listed in Table 4. The judgments as to salinity requirements have been based on an unpublished study by Maynard (1967) on the diatoms of the Florida Everglades, and on papers by Wood (1964) and Oppenheimer and Wood (1965). Those species of wide salinity tolerance are not listed. Diatoms listed as fresh-water organisms are those found to be characteristic of the fresh-water Everglades of the Shark River Valley by Van Meter (1965). The diatoms listed as brackish reflect the first appearance of any trace of saline-tolerant organisms in the samples. The marine diatoms are typically found in a marine environment and definitely indicate high salinity.

The distribution of the diatoms as a reflection of the salinity conditions is diagrammatically represented in Figure 15. A fresh-water community was found in the stippled part of the map. An intermediary zone, where most brackish organisms existed, is indicated by the lined portion of the map. Within this area, a transition from fresh water to salt water conditions takes place. In the northern quarter of this zone the diatoms present imply that the salinity was very low, since the organisms present are almost exclusively fresh-water, with only an occasional brackish-water organism being found. From this area south the diatom distribution suggests a progressive increase in salinity.

Table 4. Salinity-indicating Species of Diatoms.

I. Fresh water diatoms

Amphora sulcata
Amphora angusta
Cymbella cistula
Nitzschia palea
Nitzschia woodii
Pinnularia cuspidatum
Rhopalodia gracilis
Synedra acus (also tends to be slightly brackish)

II. Brackish water diatoms

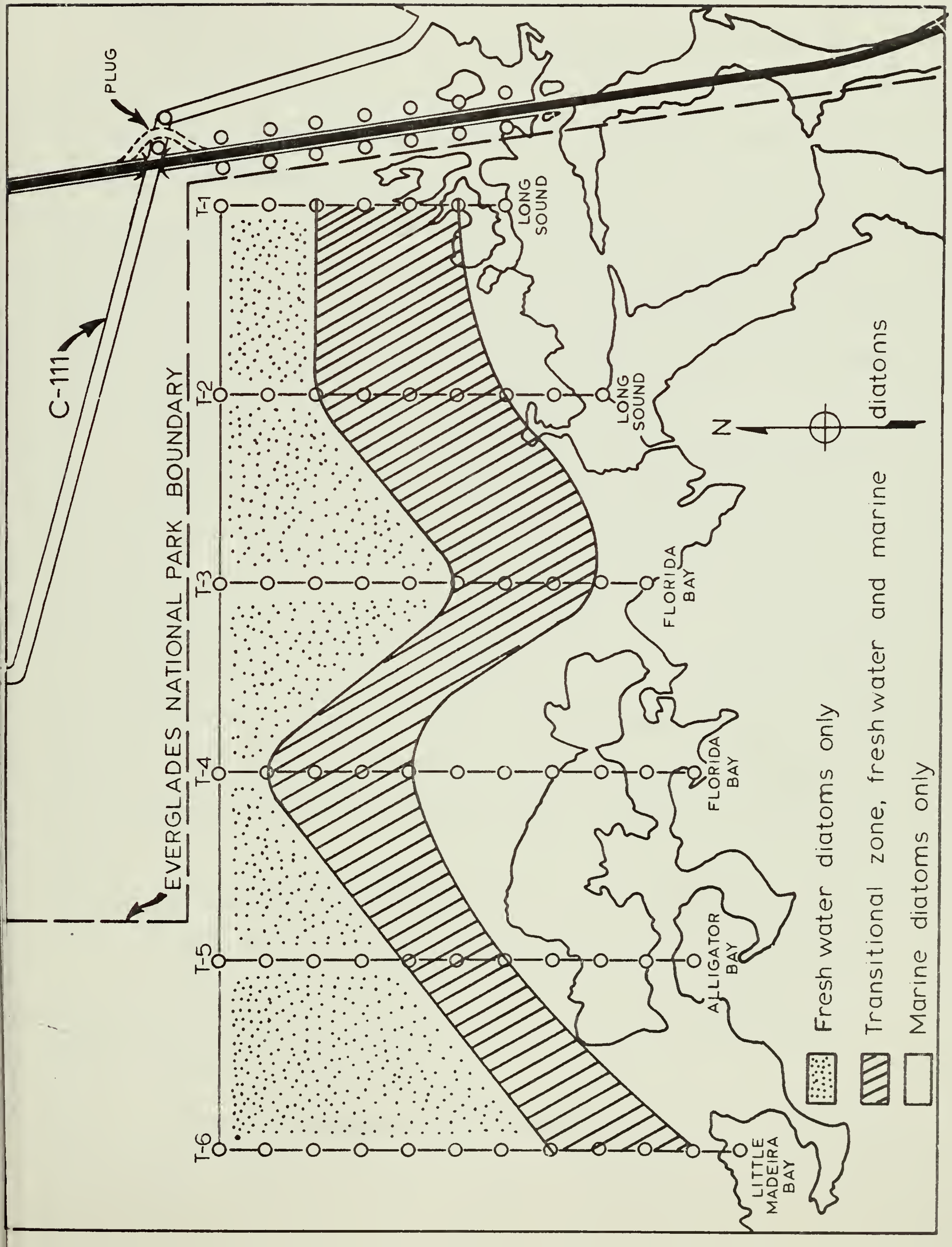
Amphora terroris
Amphora graeffii
Amphora macilenta
Navicula longa
Nitzschia closterium
Nitzschia sigma
Pleurosigma hippocampus

III. Marine diatoms

Auricula insecta
Cyclotella striata
Licmorphora flabellata
Licmorphora remulus
Licmorphora grandis
Licmorphora grandis v. divisa
Licmospnenia schmidtii
Melosira nummuloides
Nitzschia compressa
Nitzschia granulata
Nitzschia acicularis
Synedra gaillonii
Synedra ulna
Tropidoneis lepidoptera
Thallasiothrix nitzschioides
Astrionella japonica

Figure 15. Distribution of fresh-water, brackish-water and marine diatoms.

Figure 15


PLUG
C-111
EVERGLADES NATIONAL PARK BOUNDARY
T-1
T-2
T-3
T-4
T-5
T-6
LONG SOUND
LONG SOUND
FLORIDA BAY
FLORIDA BAY
ALLIGATOR BAY
LITTLE MADEIRA BAY
N
▒ Fresh water diatoms only
▨ Transitional zone, fresh water and marine diatoms
☐ Marine diatoms only

The diatoms in the periphyton mat are among the organisms which show the quickest responses to changes in the salinity of the water. Should salt water inundate the fresh-water area a rapid population change would take place. This would be especially severe if soil salt content were raised by evaporation. The organisms which now provide the most significant biomass for the organic build-up of the natural sawgrass Everglades, and which provide the food base for the birds and other animals of the area would disappear. A new flora of sparse proportions will replace the present one with an attendant reduction in organic food production.

Because diatoms and other organisms of the periphyton are sensitive to slight salinity changes, and because these organisms reproduce very rapidly, (in a matter of hours),succession to different kinds of algae, due to salt penetration,will be exceedingly rapid. Because of adsorption and other physical phenomena salt will remain in the sediments long after a return to fresh water conditions. Thus any invasion of salt will probably have a long term effect on the plant association in the area. Even if the salt water were replaced by fresh water, the original fresh water biological conditions would not return for a long time-possibly many years.

DISTRIBUTION OF THE SURFACE SEDIMENTS

Samples of the surface two inches of marl soil were collected at all transect stations after first removing the periphyton mat. The sediments were examined by X-ray diffraction to determine the presence of calcite, aragonite, dolomite, and quartz.

The calcite found was of low magnesium content, indicating fresh-water origin. Aragonite (formed in seawater) was found only in the sediments

within two miles or less landward of the northern shore of Florida Bay. The presence of magnesium-rich aragonite is interpreted to reflect the maximum extent inland of storm deposition of marine sediments from Florida Bay.

On the basis of these observations it is apparent that the northern 68.2 per cent of the area is covered by fresh-water calcite marl (Figure 16). This indicates a long history of fresh water conditions. The remaining portion is divided into an area having a mixture of calcite and aragonite, and another having calcite, aragonite and some quartz.

Hurricanes occasionally push sea water inland from the east and convert this area temporarily into a saline marsh. But hurricanes are normally accompanied by torrential rains which quickly wash out any trace of the seawater and its aragonite. Hurricane Betsy passed over this area in September 1965, and must have carried aragonite sediments into the region. The absence of aragonite in the area at the time of the present study is strong evidence of the transitory effects of such storms, and supports the evidence that the northern two thirds of the area has been a fresh-water region in character for a great length of time.

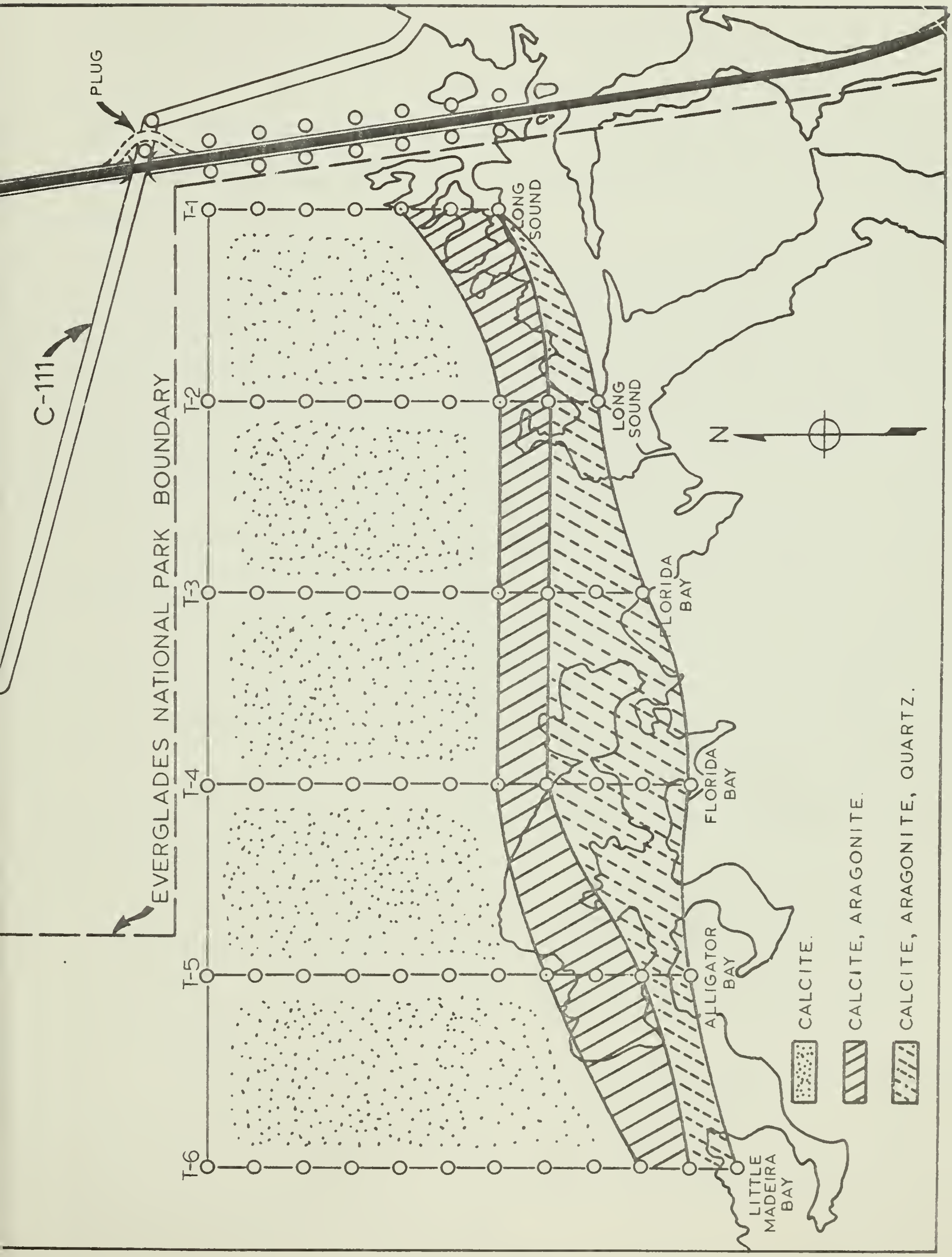
The fact that storm-driven salt water has such serious effects on plants while leaving no aragonite trace in the soils, is further evidence that salt is a quick-acting toxic substance on some plants.

SUMMARY AND CONCLUSIONS

1. A topographic map (Figure 3) of the region was constructed using the elevation of the periphyton (fibrous algal growth) on plant stems as an indication of the depth of seasonal flooding. These depths were, in

Figure 16. Distribution of calcite, aragonite and quartz, as determined by X-ray diffraction.

Figure 16



PLUG
C-111
EVERGLADES NATIONAL PARK BOUNDARY
T-1
T-2
T-3
T-4
T-5
T-6
LONG SOUND
LONG SOUND
FLORIDA BAY
FLORIDA BAY
ALLIGATOR BAY
LITTLE MADEIRA BAY
N
CALCITE.
CALCITE, ARAGONITE.
CALCITE, ARAGONITE, QUARTZ.

turn, converted to elevations (i.e., the deepest flooding represented topographic lows and the shallowest flooding indicated topographic highs). Variations in these measurements from station to station represent approximate contours. Maximum ground-level variation observed in the area was 8.6~~4~~5 inches.

2. Salinity observations show that the fresh-water (0.0 to 5.0 ppt) zone extends completely across the study area from east to west and covers 35.6 per cent of the 45.5 square mile land area studied (Figure 4, Table 5). They also showed that salinity of 20 parts per thousand and higher exist in the canal below the plug at Highway 1 while the water immediately above the plug has no measurable salinity.

3. Studies of animal distribution indicate that fresh-water animals were found over 60.0 per cent of the total land area (Table 5).

4. Studies of flowering plants indicate that fresh-water species cover 42.4 per cent of the land area (Figure 6; Table 5). Mature hammock growth formed by these species indicate long-term fresh water conditions.

5. Studies of unicellular plants of the periphyton show that fresh-water forms cover 36.0 per cent of the area under the observed dry season conditions (Table 5).

6. The nature of the sediments was determined by X-ray diffraction techniques and show that 68.2 per cent of the study area was covered by pure calcite marl, thus indicating a long period of fresh water conditions (Table 5).

It is concluded that these studies, which were arrived at separately by different investigators, offer convincing proof of the fresh-water character of soils, plants and animals of about 50 per cent of the total land area within the study area.

Table 5. Per cent coverage of fresh-water, brackish-water and low marine salinity as indicated by various tests. Total land area studied equals 45.5 square miles.

Sediment studies	Pure calcite indicating fresh-water coverage	68.2%	of total	area
Animal studies	Fresh-water organisms	60.0%	"	"
	Brackish-water organisms	24.8%	"	"
	Marine organisms	15.2%	"	"
Salinity studies	0.0 to 5.0 parts per thousand	35.6%	"	"
	5.0 to 10.0 parts per thousand	19.5%	"	"
	10.0 to 20.0 parts per thousand	28.2%	"	"
	20.0 and over parts per thousand	16.7%	"	"
Periphyton studies	Fresh-water diatoms	36.0%	"	"
	Transitional (brackish) diatoms	34.1%	"	"
	Marine diatoms	29.9%	"	"
Higher plant studies	Fresh-water vegetation	42.4%	"	"
	Salt-tolerant vegetation	57.6%	"	"

The study of the topography suggests that should saline spill-over occur from C-111 canal, there would be a southwestward spread of the effects of this spill. This would be reflected most rapidly by the unicellular algae of the periphyton, then by salt-sensitive higher plants, and shortly thereafter by a disappearance of fresh-water fishes and invertebrates.

It is also concluded that although hurricanes such as Betsy of September 1965 occasionally push sea water onto the study area, the salt is rapidly flushed back into the sea by the accompanying heavy rains that normally accompany such storms, and effects other than by outright destruction by winds is transient.

References

Chipman, R. K., 1959. Studies of tolerance of certain freshwater fishes to brine water from oil wells. Ecology, 40(2): 299-302.

Egler, F. E., 1952. Southeast saline Everglades vegetation, Florida, and its management. Vegetatio Acta. Geo-botanica. (W. Junk, Den Haag), 3(4-5): 213-265, 1950 (1952).

Gunter, G., 1938. Seasonal variations in abundance of certain estuarine and marine fishes in Louisiana with particular reference to life histories. Ecol. Mono., 8: 313-346.

Gunter, G., 1945. Studies on the marine fishes of Texas. Publ. Inst. Mar. Sci., Texas, 1(1): 1-190.

Gunter, G., 1950. Seasonal population changes and distribution as related to salinity, of certain invertebrates of the Texas coast, including the commercial shrimp. Publ. Inst. Mar. Sci., Texas, 1(2): 7-53.

Hedgpeth, J. W., 1953. An introduction to the zoogeography of the northwestern Gulf of Mexico with references to the invertebrate fauna. Publ. Inst. Mar. Sci., Texas, 3(1): 110-224.

Kilby, J. D., 1955. The fishes of two Gulf coastal marsh areas of Florida. Tulane Studies in Zool., 2(8): 176-247.

Kilby, J. D. and D. K. Caldwell, 1955. A list of fishes from the southern tip of Florida peninsula. Quar. J. Fla. Acad. Sci., 18(3).

Maynard, N. G., 1967. Unpublished progress report to National Institute of Health on Research Grant 00709.

Oppenheimer, C. H. and E. J. Ferguson Wood, 1965. Quantitative aspects of the unicellular algal population of the Texas Bay systems, Bull. Mar. Sci., 15(3): 571-588.

Reid, G. K., 1954. An ecological study of the Gulf of Mexico fishes in the vicinity of Cedar Key, Florida. Bull. Mar. Sci. Gulf and Caribb., 4(1): 1-94.

Simpson, D. G. and G. Gunter, 1956. Notes on habitats, systematic characters and life histories of Texas salt water cyprinodontes. Tulane Stud. in Zool., 4(4): 115-134.

Springer, V. G. and K. D. Woodburn, 1960. An ecological study of the fishes of the Tampa Bay area, Florida. Fla. St. Bd. Conserv., Prof. Pap. Ser., No. 1: 1-104.

Tabb, D. C. and R. B. Manning, 1961. A checklist of the flora and fauna of northern Florida Bay and adjacent brackish waters of the Florida mainland. Bull. Mar. Sci. Gulf and Caribb., 11(4): 552-649.

Van Meter, N. N., 1965. Some quantitative and qualitative aspects of periphyton in the Everglades. Unpublished M.S. Thesis, Univ. of Miami.

Wood, E. J. Ferguson, 1964. Studies in microbial ecology of the Australasian region, Nova Hedwigia, 8: 5-568.

Appendix Table 1. Presence or absence analysis, by species, of flowering plants for stations along transect 1, 2, 3, 5 from north to south. A= abundant; S= seedlings only; X= consistently present.

SPECIES TRANSECT 1 STATIONS	1	2	3	4
Acrostichum spp.	X	X	X	
Annona glabra	X	X		
Avicennia nitida				
Baccharis spp.	X	X	X	X
Batis maritima				
Blechnum serrulatum				
Borrichia arborescens			X	X
Bumelia celastrina	X	X	A	A
Calyptranthes pallens	X	A	X	
Casaurina equisetifolia			X	
Cephalanthus occidentalis				
Chamaesyce buxifolia				
Chiococca alba	X	X	X	X
Chrysobalanus icaco				
Coccoloba diversifolia				
Coccoloba uvifera	X	X	X	
Conocarpus erecta	X	X	A	A
Crinum americanum				
Dalbergia amerimnon			X	
Dalbergia ecastophyllum			X	
Distcholis spicata				
Eleocharis cellulosa	X	X	X	
Epidendrum tampense	X		X	X
Eugenia spp.	X	X	X	X
Eupatorium leptophyllum	X	X	X	X
Ficus aurea	X			
Hippocratea volubilis			X	
Ilex cassine	X			
Ipomoea sagittata	X		X	
Jacquinia keyensis				X
Laguacularia racemosa			X	X
Lycium carolinanum				
Mariscus jamaicensis	X	X	X	X
Magnolia virginiana				
Metopium toxiferum	X	X		
Mikania batatifolia	X	X	X	
Monanthochloe littoralis				
Morinda roic	X			
Myrica cerifera				
Parthenocissus quinquefolia	X	X		
Passiflora pallida				
Persea borbonia	X			
Pithecolobium quadelupense	X	X		
Pluchea sp.	X	X	X	
Randia aculeata	X	X	X	
Rapanea guianensis	X			
Rhabdadenia biflora				
Rhizophora mangle	X	X	A	A
Sabal palmetto	X			
Salicornia perennis				
Salix caroliniana				
Serenoa repens				
Sesuvium maritimum				
Smilax sp.				
Sophora tomentosa				
Solanum verbascifolium	X	X	X	X
Sporobolus virginicus				
Suaeda linearis				
Swietenia mahagoni	X	X	X	X
Taxodium distichum				
Toxicodendron radicans	X		X	
Trema micrantha	X	X		
Vanilla dilloniana	X	X		
Vitis munsoniana	X			

Appendix Table 2. Presence or absence analysis, by species, of flowering plants for stations along transect 1,2,3,5 from north to south. A=abundant; S=seedlings only; X=consistently present

SPECIES	TRANSECT 2-STATIONS	1	2	3	4	5	6	7	8	9
Acrostichum spp.					X	X				
Annona glabra				X						
Avicennia nitida						X	X	X	X	A
Baccharis spp.		X	X		X					
Batis maritima					S					A
Blechnum serrulatum		X	X							
Borrichia arborescens					X	X		X		A
Bumelia celastrina					X	X	X	X		
Calyptranthes pallens					X					
Casaurina equisetifolia						X				
Cephalanthus occidentalis										
Chamaesyce buxifolia					X	X				
Chiococca alba		X	X	X	X	X				
Chrysobalanus icaco		X	X	X						
Coccoloba diversifolia										
Coccoloba uvifera			X	X	X	X				
Conocarpus erecta		A	A	A	A	X	X	X		X
Crinum americanum										
Dalbergia amerimnon					X					
Dalbergia ecastophyllum										
Distcholis spicata					X	X		X	X	
Eleocharis cellulosa		X	X	X	X	X	X			
Epidendrum tampense					X					
Eugenia spp.				X	X			S		
Eupatorium leptophyllum						X				
Ficus aurea			X							
Hippocratea volubilis					X	X				
Ilex cassine			S							
Ipomoea sagittata			X	X	X					
Jacquinia keyensis					X	X	X	X		
Laguncularia racemosa			X		S	X	X	X		A
Lycium carolinanum						X		X		X
Mariscus jamaicensis		X	X	X	X	X				
Magnolia virginiana										
Metopium toxiferum		X								
Mikania batatifolia			X		X	X				
Monanthochloe littoralis						X				A
Morinda roic				X						
Myrica cerifera		X	X							
Parthenocissus quinquefolia		X	X	X						
Passiflora pallida					X	X				
Persea borbonia		X	X	X						
Pithecolobium quadelupense					X					
Pluchea sp..			X		X					
Randia aculeata		X			X	X				
Rapanea guianensis		S	S							
Rhabdadenia biflora										
Rhizophora mangle		X	X	X	X	X	X	X	X	X
Sabal palmetto		X			X					
Salicornia perennis										A
Salix caroliniana										
Serenoa repens					X					
Sesuvium maritimum						X				
Smilax sp.										
Sophora tomentosa		X				X	X			
Solanum verbascifolium					X	X				
Sporobolus virginicus						X	X	X		A
Suaeda linearis										
Swietenia mahagoni		X	X		X	X				
Taxodium distichum										
Toxicodendron radicans										
Trema micrantha		X								
Vanilla dilloniana			X	X						
Vitis munsoniana		X	X							

Appendix Table 3. Presence or absence analysis, by species, of flowering plants for stations along transect 1,2,3,5 from north to south. A=abundant; S=seedlings only; X=consistently present

SPECIES TRANSECT 3- STATIONS	1	2	3	4	5	6	7	8	9	10
Acrostichum spp.				X		X				
Annona glabra		X	X							
Avicennia nitida						X				X
Baccharis spp.		X				X	X			
Batis maritima						X				A
Blechnum serrulatum	A	A								
Borrichia arborescens						X	X			A
Bumelia celastrina					X	X	X			X
Calyptranthes pallens				X		X				
Casaurina equisetifolia										
Cephalanthus occidentalis										
Chamaesyce buxifolia										
Chiococca alba		X		X	X	X				
Chrysobalanus icaco	A	A	A	X						
Coccoloba diversifolia						X				
Coccoloba uvifera			X		X	X				X
Conocarpus erecta	A	A	X	X	X	X	X	X		X
Crinum americanum	X									
Dalbergia amerimnon				X	X					X
Dalbergia ecastophyllum			X							
Distcholis spicata								X	X	X
Eleocharis cellulosa	X	X	X	X	X	X	X	X		
Epidendrum tampense										
Eugenia spp.				X						X
Eupatorium leptophyllum										X
Ficus aurea		X								
Hippocratea volubilis						X				
Ilex cassine	X	X	X							
Ipomoea sagittata										
Jacquinia keyensis				X			X			X
Laguncularia racemosa				S	X	X	X	X	X	A
Lycium carolinanum						X	X			X
Mariscus jamaicensis	X	X	X	X	S	S				
Magnolia virginiana										
Metopium toxiferum	X	X	X	X	X	X				
Mikania batatifolia										
Monanthochloe littoralis										A
Morinda roic										X
Myrica cerifera	X	A	A	X	X					
Parthenocissus quinquefolia	X	X	X	X						
Passiflora pallida										
Persea borbonia	X	X	X		X					
Pithecolobium quadelupense										A
Pluchea sp.		X								
Randia aculeata					X	X	X			X
Rapanea guianensis	X	X	X	X						
Rhabdadenia biflora						X				
Rhizophora mangle	X	X	X	X	X	X	X	X	X	X
Sabal palmetto						X				
Salicornia perennis										A
Salix caroliniana										
Serenoa repens										
Sesuvium maritimum						X		X		X
Smilax sp.	X									
Sophora tomentosa		X	X	X						
Solanum verbascifolium		X								X
Sporobolus virginicus								X		X
Suaeda linearis										X
Swietenia mahagoni										
Taxodium distichum										
Toxicodendron radicans				X		X				
Trema micrantha										
Vanilla dilloniana				X	X					
Vitis munsoniana	X	X								

Appendix Table 4. Presence or absence analysis, by species, of flowering plants for stations along transect 1,2,3,5 from north to south. A=abundant; S=seedlings only; X=consistently present

SPECIES TRANSECT 5-STATIONS	1	2	3	4	5	6	7	8	9	10	11
Acrostichum spp.				X	X						
Annona glabra											
Avicennia nitida										X	X
Baccharis spp.				X				X			
Batis maritima											X
Blechnum serrulatum	A		X	X							
Borrichia arborescens						X	X	X			X
Bumelia celastrina					X	X		X			X
Calyptranthes pallens					X	X	X				
Casaurina equisetifolia											X
Cephalanthus occidentalis											
Chamaesyce buxifolia											X
Chiococca alba			X		X	X	X				
Chrysobalanus icaco	A	X	A								
Coccoloba diversifolia					X	X		X			
Coccoloba uvifera				X		X	X	X			X
Conocarpus erecta	X	X	X	X	X					X	X
Crinum americanum											
Dalbergia amerimnon											
Dalbergia ecastophyllum											
Distcholis spicata										X	X
Eleocharis cellulosa	X	X	X								
Epidendrum tampense					X	X					
Eugenia spp.					X	X	X	X			
Eupatorium leptophyllum				X	X			X			X
Ficus aurea	X				X	X					
Hippocratea volubilis				X	X	X	X	X			
Ilex cassine	A	X	X								
Ipomoea sagittata			X	X		X					
Jacquinia keyensis											X
Laguncularia racemosa				S	S	X	X	X		X	
Lycium carolinanum							X				X
Mariscus jamaicensis	X	X	X	X	X	X	X	X			
Magnolia virginiana	X										
Metopium toxiferum			X	X	X	X					
Mikania batatifolia	X			X	X	X					
Monanthochloe littoralis											
Morinda roic								X			
Myrica cerifera	A	X	X								
Parthenocissus quinquefolia	X		X								
Passiflora pallida											
Persea borbonia	X		X								
Pithecolobium quadelupense						X					X
Pluchea sp.	X				X			X			
Randia aculeata					X	X	X	X			
Rapanea guianensis	X		X	X	X		X				
Rhabdadenia biflora								X			
Rhizophora mangle	X	X	X	X	X	A	X	X		X	
Sabal palmetto	X		X								
Salicornia perennis										X	X
Salix caroliniana	X										
Serenoa repens											
Sesuvium maritimum											
Smilax sp.	X		X								
Sophora tomentosa				X		X					X
Solanum verbascifolium					X						X
Sporobolus virginicus										X	X
Suaeda linearis											
Swietenia mahagoni					X	X		X			
Taxodium distichum	X										
Toxicodendron radicans	X		X	X							
Trema micrantha											
Vanilla dilloniana					X			X			
Vitis munsoniana	X		X		X						

Appendix Table 5. Presence or absence of fresh-water, brackish-water and marine diatoms at U.S. Highway 1.

SPECIES	East Side of Highway U.S. 1 STATIONS						
	1	2	3	4	5	6	7
Amphora angusta							
Amphora sulcata							
Cymbella cistula							
Nitzschia palea							
Nitzschia woodii							
Pinnularia cuspidatum							
Rhopalodia gracilis							
Synedra acus							
Amphora terroris	X		X				
Amphora graeffii			X				
Amphora macilenta	X			X	X		
Navicula longa		X	X	X	X		
Nitzschia sigma		X	X	X	X	X	
Pleurosigma hippocampus			X	X			
Cocconeis placentula			X	X		X	X
Nitzschia closterium	X	X	X	X	X	X	
Auricula insecta		X	X				
Cyclotella striata		X	X	X		X	
Licmorphora flabellata							
Licmorphora remulus		X		X	X	X	X
Licmorphora grandis							X
Licmorphora grandis v. divisa							
Licmosphenia schmidtii							
Melosira nummuloides	X	X					
Nitzschia compressa							
Nitzschia granulata				X			
Nitzschia acicularis		X	X	X	X	X	X
Synedra gaillonii		X		X	X	X	X
Synedra ulna		X		X	X	X	X
Tropidoneis lepidoptera				X			
Thallasiothrix nitzschioides							X
Astrionella japonica				X	X		

Appendix Table 6. Presence or absence of fresh-water, brackish-water and marine diatoms at Transects 1 & 2

SPECIES		Transect 1								Transect 2								
	STATION NO.	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	9
Amphora angusta						X												
Amphora sulcata		X	X	X	X	X	X	X		X	X	X	X	X				
Cymbella cistula		X	X	X	X					X	X	X	X	X				
Nitzschia palea		X	X	X		X												
Nitzschia woodii		X	X	X	X		X			X	X	X	X					
Pinnularia cuspidatum																		
Rhopalodia gracilis		X	X							X	X							
Synedra acus		X	X	X	X	X	X			X	X	X	X	X				
Amphora terroris					X		X	X						X	X			
Amphora graeffii								X							X			X
Amphora macilenta						X	X	X							X	X		X
Navicula longa																		
Nitzschia sigma					X	X							X					X
Pleurosigma hippocampus					X			X	X						X	X		X
Cocconeis placentula								X									X	
Nitzschia closterium						X	X	X					X		X	X	X	X
Auricula insecta																X		X
Cyclotella striata																		X
Licmorphora flabellata									X								X	
Licmorphora remulus																		X
Licmorphora grandis																		
Licmorphora grandis v. divisa																		
Licmosphenia schmidtii																	X	X
Melosira nummuloides															X	X		
Nitzschia compressa								X							X	X	X	
Nitzschia granulata								X							X	X		
Nitzschia acicularis								X										X
Synedra gaillonii																	X	X
Synedra ulna								X								X	X	X
Tropidoneis lepidoptera					X	X										X	X	X
Thallasiothrix nitzschioides																		
Astrionella japonica																		

Appendix Table 7. Presence or absence of fresh-water, brackish-water and marine diatoms at Transects 3 & 4

	Transect 3										Transect 4									
SPECIES STATION NO.	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	10	11
Amphora angusta																				
Amphora sulcata	X	X	X	X	X						X	X		X						
Cymbella cistula	X	X	X	X							X									
Nitzschia palea			X	X	X						X	X								
Nitzschia woodii	X	X	X	X	X						X	X								
Pinnularia cuspidatum	X																			
Rhopalodia gracilis											X	X								
Synedra acus	X	X	X	X	X	X	X				X	X	X	X		X				
Amphora terroris													X				X		X	
Amphora graeffii													X						X	
Amphora macilenta							X	X		X			X	X				X	X	X
Navicula longa								X	X	X				X	X	X	X	X	X	X
Nitzschia sigma										X			X				X			X
Pleurosigma hippocampus							X	X	X	X							X			
Cocconeis placentula							X	X	X	X					X	X	X			
Nitzschia closterium								X		X			X	X	X	X			X	X
Auricula insecta																			X	
Cyclotella striata									X											X
Licmorphora flabellata																				
Licmorphora remulus										X										
Licmorphora grandis																				
Licmorphora grandis v. divisa																				
Licmosphenia schmidtii																				
Melosira nummuloides									X											
Nitzschia compressa																				
Nitzschia granulata								X		X										X
Nitzschia acicularis							X	X		X						X	X	X		X
Synedra gaillonii										X				X		X	X	X	X	
Synedra ulna								X	X	X								X		X
Tropidoneis lepidoptera																				
Thallasiothrix nitzschioides																				
Astrionella japonica																				

Appendix Table 8. Presence or absence of fresh-water, brackish-water and marine diatoms at Transects 5 & 6

	Transect 5											Transect 6											
SPECIES STATION NO.	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5	6	7	8	9	10	11	12
Amphora angusta	X											X	X	X	X	X	X	X					
Amphora sulcata		X	X	X	X	X	X																
Cymbella cistula	X	X	X	X	X	X						X	X	X	X	X	X	X	X	X	X		
Nitzschia palea	X	X	X	X	X							X		X	X	X	X	X	X		X		
Nitzschia woodii	X		X	X	X							X		X	X		X	X	X	X	X		
Pinnularia cuspidatum												X	X	X	X	X							
Rhopalodia gracilis	X	X	X									X	X	X	X	X	X	X	X	X			
Synedra acus	X	X	X	X	X	X	X	X				X		X			X	X	X	X	X		
Amphora terroris											X												
Amphora graeffii						X	X				X												
Amphora macilenta					X	X	X	X		X	X										X	X	X
Navicula longa						X	X	X		X											X	X	X
Nitzschia sigma								X		X											X		
Pleurosigma hippocampus				X				X		X											X		X
Cocconeis placentula						X	X	X		X	X										X	X	
Nitzschia closterium						X	X	X		X											X	X	
Auricula insecta						X	X			X									X	X	X	X	X
Cyclotella striata											X												X
Licmorphora flabellata																							
Licmorphora remulus																						X	X
Licmorphora grandis																							
Licmorphora grandis v.divisa																		X					
Licmosphenia schmidtii											X												
Melosira nummuloides											X												
Nitzschia compressa																							
Nitzschia granulata										X													X
Nitzschia acicularis							X	X		X	X								X		X	X	X
Synedra gaillonii						X				X	X											X	X
Synedra ulna										X	X											X	X
Tropidoneis lepidoptera											X										X		X
Thallasiothrix nitzschioides																		X	X	X			
Astrionella japonica																							

Appendix Table 9. Continuing observation of salt-sensitive living reference plants

The first station on transects 1 through 5 were re-visited on March 7, 1967 with the specific objective of locating living plants of the species that has been observed to have been damaged or killed by hurricane Betsy, September 1965. These plants can be checked at intervals in the future for signs of salt damage. In all instances they are just within the Park boundary.

Transect 1, Station 1

Vitis (grape) seedlings in hammocks (not seen to the south on this transect) were marked as indicator plants. The site is Alexander's old mat-net experiment area, S.E. of seismic hole marked by a board and bottle marker. A color photograph was made.

1. Stake with aluminum tag - 1 seedling - cotyledonary and second leaf stage
2. Stake as above - 2 seedlings near buttonwood log
3. Stake as above - 4 seedlings - a group of 3 plus 1
4. Six feet farther (SE) - 1 grape beginning to climb at base of an *Annona glabra*
5. To N.E. - about 12' - red bay root sprouted

This hammock is extremely important to the project as it is the closest to the intersection of U.S. 1 and C-111 and the salt sensitive plants were nearly 100% eliminated by hurricane Betsy. Hence, young plants of *Vitis*, *Smilax*, *Rapanea*, *Persea*, *Chrysobalanus*, and *Myrica* that occur here immediately become excellent check species for salt damage.

Transect 2, Station 1

First hammock to west and north of flag marking the transect station. Seriously storm damaged, canopy opened, marked as follows: reference large bay stump (in west side) with Vanilla growing on it.

1. Stake with aluminum tag, 1 Vitis seedling 6" tall, west of stump
2. Stake as above - 1 Vitis seedling 6" tall
3. S.W. of stump - Vitis twisted around dead tree trunk to height of 5' (Al. tag)
4. S.E. of stump (20') large vine twisted on stakes (Al tag)

Hammock west of previous - small open pool on N.E. side First Cephalanthus seen below C-111 (fresh water plant found in all other transects to west at increasing frequency). Other plants present - Sophora (large plants), Ilex, Buttonwood, and Ficus, dense sawgrass.

Reference plants:

1. Myrica (wax myrtle) on east side near hurricane drift line- first living specimens seen south of C-111
2. Cocoplum - mostly dead - occasional survival
3. Persea - 5" DBH dead

Transect 3, Station 1

West of third marker. Cephalanthus and Blechnum thick. Red mangrove and buttonwood common - trand-like.

Reference plants:

1. Vitis - good condition
2. Cocoplum - good condition
3. Myrica - good condition

4. Rapanea - good condition

5. Smilax - first vine seen alive (S. of small gator hole?)

Second hammock S.E. of Park boundary marker (E. and S. of hammock just described) and about 75 yards inside park - two large red bays close together in N. side and 1 larger opposite in S. side.

Reference plants:

1. Rapanea - good condition
2. Myrica - good condition
3. Cocoplum - good condition

Transect 4, Station 1

East of flag marker - Hammock near boundary.

Reference plants.

1. Cocoplum - good condition
2. Rapanea - good condition
3. Myrica - good condition
4. Smilax - one alive and one dead vine (large vines in canopy)
5. Persea - one dead DBH 4"
6. Taxodium - one dead

Transect 5, Station 1

Small hammock (closest one of 2 S.E. of small pool) Leaning cabbage palm on N.E. edge

Reference plants:

1. Taxodium - first living, 1 at 12' and 1 at 4'
2. Rapanea - good condition
3. Myrica - good condition

4. Cocoplum - good condition

5. *Persea* - seedlings to 6" and larger trees

6. *Magnolia virginiana* - first trees seen alive (This tree was killed out completely 3 miles N. of C-111 near U.S. 1 after Betsy.)